Green Manures and Manuring in the Tropics

Including an Account of the Economic Value of Leguminosæ as Sources of Foodstuffs, Vegetable Oils, Drugs, &c.

BY

P. de SORNAY

Chemist

Ex-Assistant Director of the Station Agronomique of Mauritius; Laureate of the Association des Chimistes de Sucrerie et de Distillerie de France et des Colonies; Laureate of the Société Nationale d'Agriculture de France

TRANSLATED BY

F. W. FLATTELY

Demonstrator and Research Student in the Department of Zoology, University College of Wales, Aberystwyth

FROM THE WELL-KNOWN WORK

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THIS WORK WAS AWARDED A GOLD MEDAL
BY THE SOCIÉTÉ NATIONALE D'AGRICULTURE DE FRANCE

To my esteemed Master and Friend

M. P. BONÂME.

A token of deep gratitude and sincere admiration.

PREFACE.

It is my pleasant duty to introduce to the agricultural public the work of M. P. de Sornay on the tropical Leguminosæ.

M. de Sornay, originally a student at the Agricultural Station, has for the past nine years been attached to the staff as Assistant Director.

The family of the Leguminosæ contains a large number of species whose practical applications, chiefly in warm climates, are of great interest, and M. de Sornay's treatise on them is the best proof of the extent of his knowledge and his zeal.

We cannot but be indebted to the author for having put together such a mass of information in so concise and instructive a form. Besides a description of the characters and practical uses of tropical Leguminosæ, the reader will find a study of the peculiar agricultural properties of this family, which forms a special class of its own in the vegetable kingdom.

Clear and simple in plan, and unencumbered by useless comments, it contains a scholarly account of the subject tempered by the sound judgment of the writer. His personal contribution is of the greatest value.

This contribution consists of numerous analyses of plants, an account of the observations on the cultivation of each, the advantages to be derived from them, and their manifold uses in industry and agriculture. Once read the work cannot fail to be appreciated.

There is no doubt as to the future success of this book of M. de Sornay, and I am happy to have this opportunity of offering him my congratulations and of assuring him of my esteem.

P. BONÂME,
Director of the Agricultural Station of the Island of Mauritius.

INTRODUCTION.

It is specially gratifying to have been chosen by the author to give an introduction to this book, since for many years past we have had numerous opportunities of appreciating the value and interest of the works of M. de Sornay.

The family of the Leguminosæ is one of the most important in the plant kingdom, not only on account of the diversity of its species, but because of the practical value of its products, either as food, or in trade, or from a farming point of view.

The leguminous plant, in fact, is one of which the nature and physiology are most complex. Its peculiar property of fixing atmospheric nitrogen has been the cause of a number of controversies, and the study of it has aroused the interest of numerous scientists, who, at any rate at first, were by no means in agreement. To-day it is practically universally accepted that this plant does possess the property of fixing atmospheric nitrogen, but a Scotch scientist has endeavoured to confute the idea of this faculty being confined exclusively to the Leguminosæ. He has brought forward a number of experiments and arguments aiming at showing *that the Leguminosæ only share, although in a more marked degree*, the faculty common to all plants of absorbing atmospheric nitrogen by means of organs situated on their leaves.

However that may be, the point of greatest interest to us is to acquire a better knowledge of the plant, not from the physiological point of view (these principles to-day being sufficiently well established), but rather from the economic, farming, and general agricultural point of view.

The importance of this class of crop and the advantages to be derived from it are well known, and all who

are interested in tropical plants will find in this work information of the utmost value.

M. de Sornay, who for a number of years has been a member of the staff of the Agronomic Station at Mauritius, had already published, some time ago, in the *Bulletin* of the Station, a short treatise on the Leguminosæ.

Encouraged by the favourable reception accorded to this treatise, he wished to gather into one volume a number of scattered works on the economic Leguminosæ of the Tropics. This task has demanded from the author a large amount of time, patience, and research; not only has he personally carried out a number of analyses, but he has further given us the results of those made before his own.

The book, in fact, forms a complete survey; the author deals with each question in full detail, he is not content merely to refer to such-and-such another work, but is anxious that every chapter may form a complete whole, where the reader may find all the information he can require. He wishes his book to be a guide within the reach of all.

M. de Sornay excuses himself, however, for not always having given as much detail as he would have desired; he has not always been able to escape the difficulty of finding the references necessary, but we who for many years have followed M. de Sornay's researches, and have actually seen him at work, feel convinced that wherever the references have been scanty they have been replaced by an exceptionally valuable personal experience and by the advice of his esteemed master and friend, M. Bonâme.

The scheme of the work, which has been planned with the greatest clarity, may be summarized as follows:—

An account of the theories on the fixation of nitrogen from the air by the Leguminosæ.

Value of restorative food and fodder plants, origin, description, cultivation, varieties, yield, uses of numerous species: pea-nut, Bambarra ground-nut, jack bean, pigeon-

pea, chick pea, clover, yam bean, lentil, sulla, Bengal bean, &c.

Comparison between various rotation peas.

Investigation of the manganese, prussic acid, and starch in the Leguminosæ.

Value of the Leguminosæ from an agricultural point of view; their use as animal fodder and in pasture.

Plants yielding rubber and resin: Leguminosæ producing tanning matters, dyes, building timber, drugs, textile materials, &c. Leguminosæ as ornamental plants.

Pests attacking the Leguminosæ.

Bibliography.

Seventy-five to eighty hitherto unpublished plates of sketches and photographs lend additional interest to M. de Sornay's work.

We wish this work all the success it deserves, and can hardly fail to obtain; for not only is it the product of long and unremitting toil, but it will certainly lighten the tasks of numerous other workers. It will take first place among the good books dealing with tropical agriculture.

H. PELLET.

TRANSLATOR'S NOTE.

In view of the very great amount of work and the possible loss in accuracy which conversion of the numerical data in M. de Sornay's book would have entailed, it has been decided to retain the metric system throughout. I have, however, considered it advisable to dispense with the old French measure, the "arpent," frequently occurring in the original, and to state all calculations of area, yield, &c., in terms of hectares. For the sake of convenience, a table of French and English equivalents is included at the beginning of the book.

In discussing the fruit of the Leguminosæ, the word "pod" has been used to denote the whole fruit with its contained seeds, and the word "husk," the equivalent of "shell," or the American "hull," to signify the pod emptied of its seeds.

Owing to the War, communication with the author has been difficult, consequently no attempt has been made to modify the plan of the original in any way and the translation remains somewhat more literal than might have been the case had closer collaboration been possible. A complete set of proofs, however, has passed through M. de Sornay's hands and such corrections as he has made have been incorporated with my own.

I wish to take this opportunity of expressing my thanks to Mr. C. L. Walton, M.Sc., and Mr. W. E. Whitehouse, of the University College of Wales, Aberystwyth, for considerable help in the work of revision.

F. W. FLATTELY,
International Institute of Agriculture,
Rome.

CONTENTS.

TABLE OF FRENCH AND ENGLISH EQUIVALENTS.

1 Mile (U.K.) = 1,609 metres.
1 Yard (U.K.) = 91·44 centimetres.
1 Foot (U.K.) = 30·48 centimetres.
1 Inch (U.K.) = 2·54 centimetres.
1 Square Yard (U.K.) = ·836 sq. metre.
1 Kilometre = 1,093·6 yards.
1 Metre = 39·37 inches.
1 Arpent = 1·04 acres.
1 Hectare = 2·47 acres.
1 Acre (U.K.) = 0·40468 hectares.
1 Acre (U.S.A.) = 0·40469 hectares.
1 Gramme = $\frac{1}{1000}$th of kilo = 15·432 grains.
1 Hectogramme = $\frac{1}{10}$th of kilo = 3·5 oz.
1 Kilogramme or kilo = 2·2046 lb.
1 Quintal of 100 kilos = 220·46 lb.
1 Metric ton of 1,000 kilos = ·984 ton.
1 Bushel of wheat (U.K.) = ·27216 quintals.
1 Bushel of linseed (U.K.) = ·23587 quintals.
1 lb. (English) = ·45359 kilo.
1 Quarter of wheat (U.K.) = 2·17724 quintals.
1 Quarter of linseed (U.K.) = 1·88694 quintals.
1 Ton (U.K.) = 10·16047 quintals.
1 Litre = 1·7598 pts., or ·88 quart.
1 Pint = ·56825 litre.
1 Gallon (8 pints) = 4·546 litres.
1 Bushel (8 gallons) = 36·3677 litres.
1 Quintal per hectare = 89 lb. per acre, or nearly 1½ bushels of wheat at 60 lb. to the bushel.

THERMOMETER COMPARATIVES.

Centigrade	Réaumur	Fahrenheit
−20	−16	−4
0	0	+32
+10	+8	50
25	20	77
50	40	122
60	48	140
100 (boiling)	80	212

GREEN MANURES AND MANURING IN THE TROPICS.

CHAPTER I.

GENERAL REMARKS.

The family of the Leguminosæ, which numbers not less than 7,000 species distributed over every portion of the terrestrial globe, contains, according to Van Tieghem, 430 genera. It includes herbs, shrubs (large and small), and trees of very varying aspect, some species climbing by means of foliar tendrils, *e.g.*, peas, &c.

The Leguminosæ are dialypetalous, dicotyledonous plants, in which the essential character is that the pistil (female organ) is almost invariably formed of a single free carpel. The fruit which results from the fertilization of this carpel is usually a pod (*legumen*) or legume, and to this the family owes its name.

The seeds contain an albuminous substance, "legumin," which is of great importance from a technical point of view. It is certain that owing to its wealth of nitrogen it plays the chief part in the nutritive value of those plants which contain it. Legumin in its ground composition closely resembles other proteid principles contained in plants, but the percentage of nitrogen present is higher.

The proportion of this body present, in fact, is 18·5 per cent., whereas in albumen and casein the proportion reached is only 16 per cent.

The Leguminosæ are generally divided into three great sub-families: Cæsalpineæ, Mimoseæ, and Papilionaceæ.

Whilst the Papilionaceæ adapt themselves to every climate and are found distributed from the Equator to the Poles, the Mimoseæ and Cæsalpineæ, on the other hand, prefer tropical climates, where they are encountered in large numbers.

The Papilionaceæ are plants which are well known and easily identifiable by their inflorescence. The calyx has five sepals, the corolla is composed of five petals: that which is superior and completely external is called the *standard;* those which are lateral, their upper margins overlapped and lower margins overlapping, are the *wings;* those which are inferior, with their lower margins generally mutually adherent, constitute the *keel.*

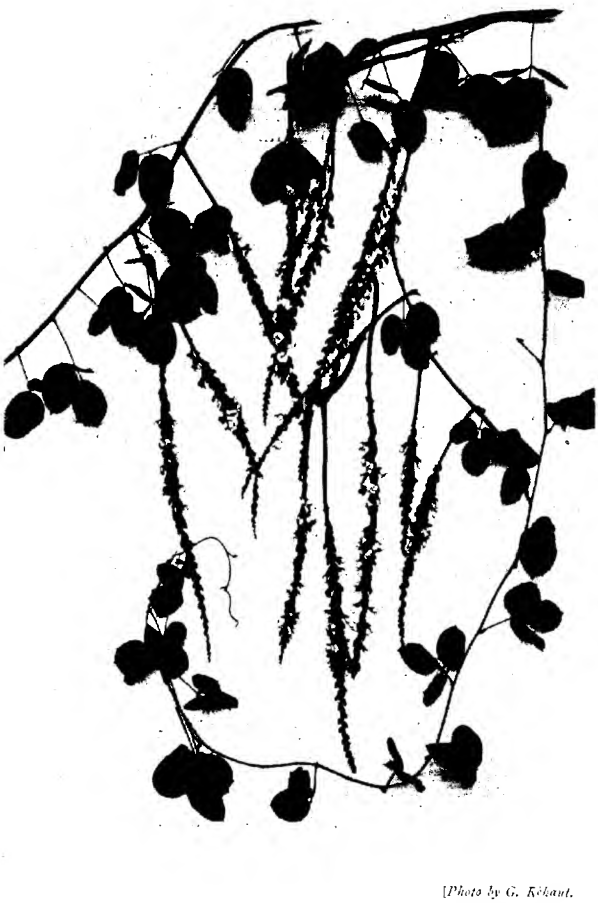
The Papilionaceæ are divided into eleven tribes:

I. Podalyrieæ	...	... Podalyria.
II. Genisteæ	...	... Crotalaria, Lupinus, Genista.
III. Trifolieæ	...	... Medicago, Melilotus, Trifolium.
IV. Loteæ ...	...	.. Lotus, Astragalus.
V. Galegeæ	...	... Indigofera, Tephrosia.
VI. Hedysareæ	...	... Arachis.
VII. Vicieæ ...	...	... Vicia, Lens, Lathyrus, Pisum.
VIII. Phaseoleæ	...	... Glycina, Mucuna, Phaseolus, Voandzeia, Dolichos.
IX. Dalbergieæ	...	.. Dalbergia.
X. Sophoreæ	...	... Sophora.
XI. Swartzieæ	...	... Swartzia.

The Cæsalpineæ possess flowers which closely resemble those of the Papilionaceæ, only differing from them in the æstivation of their corolla, which is imbricate in such a manner that the posterior petal is enveloped instead of enveloping. It is in this group that the flowers are most irregular, for one meets with all sorts of anomalies, atrophy of stamens, petals, &c. Such is the case in the locust tree, which has no corolla.

The Cæsalpineæ are divided into six tribes:—

I. Sclerolobieæ	...	...	... Melanoxylon.
II. Eucæsalpinieæ	...	...	... Cæsalpinia, Hæmatoxylon.
III. Cassieæ...	...	..	... Cassia.
IV. Bauhinieæ	...	...	... Bauhinia.
V. Amherstieæ	...	...	... Tamarindus.
VI. Cynometreæ	...	...	... Copaifera.



[Photo by G. Rėkaut.

FIG. 1.—Species of Leguminosæ. Réduit (Mauritius).

The Mimoseæ are distinguished from the two other sub-families by the unvarying regularity of their flowers; that is to say, every variety of the Mimoseæ has the same type of flower, in which the corolla is valvate with one or several sepals. Everybody is acquainted with the flower of the acacia, which, with the sensitive plant (*Mimosa pudica*), is the most familiar of Mimoseæ, and all the remaining species, like these two, have the flowers arranged in globular capitula. In certain parts of the flower the Mimoseæ may show variation, but it is not within the scope of this work to detail the parts of flowers in each species.

Here we only have five subdivisions :—

I.	Parkieæ	Pentaclethra.
II.	Adenanthereæ	Adenanthera.
III.	Eumimoseæ	Mimosa.
IV.	Acacieæ	Acacia.
V.	Ingeæ	Albizzia.

These subdivisions have been taken from Vesque's "Botanique," and although all botanists are not agreed as to this classification, the above groups seem to be the best.

Among the Dicotyledons, the immense family of the Leguminosæ is one of the most characteristic and, at the same time, one of those in which the type of organization undergoes the most far-reaching modifications. It ranks as one of the most important in nature, and renders manifold service to the human race.

The Leguminosæ inhabit every clime; though extremely numerous in the torrid and temperate zones, they also have representatives in Arctic latitudes, on the very boundary line of the vegetation limit. These plants are of every dimension, from the tiniest herbs to the most gigantic trees. Commerce and domestic economy obtain from them all kinds of products: seeds of value for food or oil, farinaceous tubers, fodder, fertilizers as by-products, woods highly valued for their beauty or their strength, dyes and medicinal matter, and finally a prodigious variety of ornamental herbaceous or arborescent plants.

Their botanical characters are as follows: Leaves alternate, persistent or caducous, nearly always furnished with stipules, sometimes foliaceous, sometimes spiny, occasionally reduced to simple glands; these leaves are only rarely simple, being usually pinnate, that is to say, composed of leaflets arranged in pairs along a common axis, with or without a terminal leaflet; the pinnate leaf may be often simply trifoliate or even reduced to a single leaflet. In certain genera they are doubly or trebly pinnate, as if the leaflets themselves had split up into secondary leaflets. The flowers are almost universally hermaphrodite, but they sometimes become unisexual through atrophy (the locust tree, for instance).

The corolla is polypetalous and the stamens usually ten in number; several groups, however, form an exception under this heading through the monopetalous condition of the corolla and the indefinite number of stamens. The ovary, invariably free, develops into a legume or pod.

The Papilionaceæ constitute the majority of the family of the Leguminosæ. Their leaves are nearly always compound, often trifoliate, sometimes reduced to the terminal leaflet, and then apparently simple. More rarely all the leaflets disappear, and their place is taken by a foliaceous dilatation of the petiole, which, in this case, goes by the name of a phyllode. It can even happen that the petiole as well as the lamina may be lacking, and the leaves may be replaced by foliaceous prolongations of the stalk, which is then said to be winged. In a certain number of genera the distal leaflets, reduced to their median nervure, are transformed into tendrils, as in the common or sweet pea.

In the Cæsalpineæ, the leaves are pinnate with or without a terminal leaflet, sometimes bi- or tri-pinnate, rarely perfectly simple.

In the Mimoseæ the leaves are, in the majority of cases, bi- or tri-pinnate. In a small number of species they are sensitive; that is to say, capable of performing apparently

spontaneous movements at the slightest contact with an extraneous body.

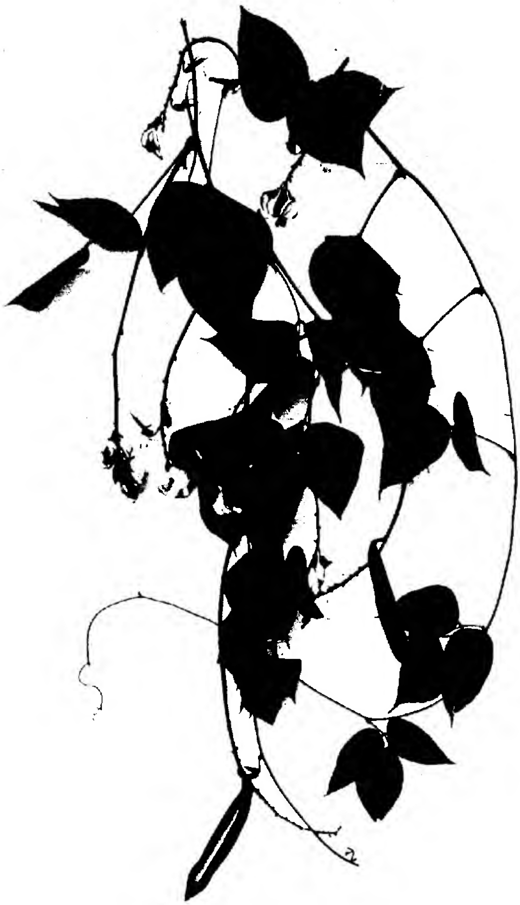
In every country and among every people from time immemorial the Leguminosæ have played a most important part. Do not we see Dioscorides, Galen, and Pliny speaking of the cultivation of the green pea? And did not Esau exchange his birthright for a mess of lentils?

Ezekiel, David, and Samuel have described the existence of the bean, and it was introduced into China 2,822 years before the Christian era.

The attention of mankind from the earliest times has been directed to these valuable and remunerative plants. Gradually, all those which have proved of profit have been recorded, and at the present day the list of their names is an exceedingly long one.

In more recent times, scientists have not been content merely to record and to cultivate these plants; they have studied their properties and their nature as well. Firstly, they have been struck by the phenomenon of the cultivation of Leguminosæ enriching the soil in nitrogen instead of impoverishing it; they have realized all the capabilities such plants may offer, and by their researches have benefited the world at large. These researches have resulted in the regeneration of exhausted soils by intensive cultivation; the rational cultivation of valuable species of timber; the wise employment of fodder in the feeding of cattle; the extended use of inter-crops; the extraction of certain oils and the extension of manifold industries which have enriched man and facilitated his means of existence.

We shall have occasion, in the course of this work, to study more particularly the chief species of this order of plants. Within bounds so restricted as ours it is impossible to mention all the existing Leguminosæ. We shall be obliged to limit ourselves to discussing those which man has been able to turn to his advantage, and which are distributed throughout the Tropics.



[Photo by G. Réhaut.

FIG. 2.—Leguminous plant. Réduit (Mauritius).

As it is inevitable that several will escape attention, we must claim the reader's indulgence and ask him to take into account only our wish to render this work of value to those who are starting work in the Tropics.

In order to make reference easier we shall retain the established divisions, *i.e.*, Papilionaceæ, Cæsalpineæ, and Mimoseæ, and we shall class all plants among these sub-families without regard to the subdivisions already enumerated, which are useful to know, but which have no first-rate importance so far as the culture and exploitation of these plants are concerned.

CHAPTER II.

ACCOUNT OF THE THEORIES ON THE ABSORPTION OF NITROGEN FROM THE AIR BY THE LEGUMINOSÆ.

CHIEF RESEARCHES.

THE function of fixation of atmospheric nitrogen by plants is a problem which not only is of interest to scientists under the head of plant physiology, but which also has its primary application in the fertilization of the soil, and it is particularly from this double point of view that it is of interest to agriculturists. From the day when observant minds were eager to understand the effect of crops on the soil which had borne them—which is looking back thousands of years, seeing we have to deal with agricultural scientists like Columella—it was noted that the soil seemed improved after a crop of leguminous plants, such as lupin, vetch, &c., and we may say that all work undertaken on the subject of fixation of atmospheric nitrogen has its origin in these observations, since they were made in order to understand the reason for the soil, after having produced the leguminous plants supplying a considerable amount of nitrogenous materials in the shape of fodder and seed, being found subsequently just as rich, if not richer, in this element, considered as being the most potent in plant growth.

However, at the start, which represents an epoch now fairly remote, seeing that authentic research only began with Boussingault in 1838, attention was chiefly paid to considering whether plants actually did absorb nitrogen from the air. At this period this faculty was not only assigned to the Leguminosæ, but to all plants, and Boussingault himself

carried out his researches on the Gramineæ as well as on the Leguminosæ.

Priestley and Théodore de Saussure were the first to employ scientific methods in order to demonstrate this absorption. In fact, Priestley, in his work "Experiences and Observations of Different Kinds of Air," relates how he placed a plant of *Epilobium hirsutum* in a vessel 10 in. high by 1 in. wide, which at the end of a month had absorbed seven-eighths of the available nitrogen.

Ingenhoutz, in his "Expériences sur les Végétaux," affirms that all plants have the power of absorbing nitrogen gas.

Théodore de Saussure gives an account, in his "Recherches chimiques sur la Végétation," of the experiments he made with plants placed either in atmospheric air or in pure nitrogen, and from which he draws a negative conclusion; that is to say, he denies the faculty of plants for absorbing nitrogen from the air.

Théodore de Saussure gives his conclusions thus: "If nitrogen is a simple body, if it is not an element of water, one must be forced to recognize that plants are only able to assimilate it in the form of plant and animal extracts and ammonia vapours, or other compounds soluble in water, which they are able to absorb from the soil and from the atmosphere."

Woodhouse and Senebier came to the same conclusion. Sir Humphry Davy (1812) brought no new contribution to the subject of the fixation of atmospheric nitrogen, but greatly encouraged through his work the application of science to agriculture.

In 1838, Boussingault, remarking that crops made use of nitrogen, and that the soil fertility was maintained without the addition of nitrogenous manures, was of the opinion that the greater part of this nitrogen must of necessity come from the atmosphere.

With the object of checking the likelihood of this

hypothesis, Boussingault carried out several experiments in which he employed a calcined soil, one thus completely deprived of the slightest traces of organic matter. This soil he watered with distilled water.

Seeds, representing the average and comparable to those planted, were taken, weighed and analysed.

	Nitrogen in the seeds	Nitrogen harvested	Gain or loss in nitrogen
Clover ...	0·110 ...	0·120 ...	+ 0·010
,, ...	0·114 ...	0·156 ...	+ 0·042
Wheat ...	0·043 ...	0·040 ...	− 0·003
,, ...	0·057 ...	0·060 ...	+ 0·003
Pea ...	0·047 ...	0·100 ...	+ 0·053

From these results Boussingault argued that the gain in nitrogen might have accrued either from the absorption of atmospheric ammonia or from the fixation of nitrogen gas, and he favoured the second hypothesis. Liebig did nothing to further the question of the absorption of nitrogen from the air, although his works have benefited agricultural science enormously.

From 1849 to 1852, M. Georges Ville carried out experiments on the assimilation of nitrogen gas by plants, and came to a conclusion favouring the theory. We shall discuss these works later, and return at present to those of Boussingault, carried out from 1851 to 1853 in order to check his original experiments.

The method followed was, in principle, the same as in 1838, only being modified in a few details. Thinking that the slight gain in nitrogen obtained in his first experiments might have been derived from traces of ammonia in the open air in which the plants had grown, Boussingault removed his second lot of plants from the air and only allowed them an atmosphere saturated with 7 to 8 per cent. of carbonic acid.

Appended are the results of five experiments:—

1st.	Lupin (2½ months) ...	loss in nitrogen ...	0·0009
2nd.	Dwarf bean (2½ months)	gain ,, ...	0·0003
3rd.	,, (3 months)	gain ,, ...	0·0006
4th.	,, (3½ months)	loss ,, ...	0·0010
5th.	,, (2¼ months)	loss ,, ...	0·0010

Boussingault concluded from these results that plants did not assimilate nitrogen gas from the atmosphere.

This scientist brought his researches to a close by a sixth experiment in which he supplied the plant with a nitrogenous manure with the object of discovering whether such a manure would facilitate the absorption of nitrogen by the plant.

He realized that the presence of nitrogenous matter in the soil did not favour the assimilation of nitrogen gas.

We are thus in touch with those early researches which were confirmed later by the scientists, Lawes, Gilbert, and Pugh, of the Rothamstead Laboratory, and which allowed M. Grandeau, whose scientific reputation is fully established, to say, in 1879, in one of his lectures at the French School of Forestry, that scientists were unanimous in denying to plants, in any degree whatsoever, the faculty of assimilating nitrogen gas.

M. Georges Ville, still undeterred, began a series of experiments in 1849, the results of which were first communicated to the Academy in 1852.

Professor Ville started by showing that if in the experiments of Boussingault, already cited, the plants absorbed no nitrogen from the air, the reason was because a plant is unable to develop normally in a limited atmosphere.

These experiments were carried out in the "Jardin des Plantes" in Paris, before a Commission from the Académie composed of Dumas, Regnault, Payen, Decaisne, Péligot, and Chevreul, and they lasted two months, from August 4th to October 12th, 1854. The actual methods employed, which were subjected to a good deal of criticism, are of no great account, but the gist of the matter was that at the conclusion of its report the Commission expressed itself as follows:—

"The experiments which M. Ville has carried out at the Natural History Museum confirm the conclusions he has drawn from his earlier researches."

However, until the publication of Hellriegel's researches

this theory of Ville's was not accepted. Students were taught that plants absorbed nitrogen from the air, but the theory propounded by Ville to account for this assimilative property was not admitted. Later on, Ville's experiments were confirmed by Mène and Roy.

These contradictions induced other scientists to attempt to solve the problem afresh, and in the Rothamstead Laboratory Messrs. Lawes, Gilbert and Pugh renewed experiments, to reach a final conclusion agreeing with that of Boussingault.

These English scientists, however, seem very cautious in the conclusion of their report, when they say that in carrying out numerous experiments on the Gramineæ under widely differing conditions of growth, assimilation of free nitrogen has never been detected.

In the experiments on the Leguminosæ they found growth was less satisfactory and the limits of variation were smaller, but the results recorded showed no assimilation of free nitrogen. They thought it desirable that further experiments should be carried out on these same plants under more favourable conditions.

A doubt thus seems to be present in the minds of the English scientists, in spite of their being better prepared than any others by twenty years of practical experiments of the nitrogen demands of crops.

In 1873 H. Dehérain expressed the opinion that atmospheric nitrogen might have the property of entering into combination with certain ternary substances—cellulose, glucose—and, hence, with organic substances in the soil in course of decomposition.

M. Th. Schloesing proved that the experiments which allowed M. Dehérain to form this opinion were of no value owing to the manifold grounds of error, and, wishing to be thoroughly convinced, he repeated the majority of these tests after eliminating these possible sources of error. The gist of his conclusions was that neither by using sealed

tubes, nor by passing the nitrogen through water, nor by varying the proportions between the reacting substances, nor by exposing the soil to an atmosphere deprived of oxygen, was he able to obtain nitrogen fixation as a result.

French scientists have not been alone in devoting attention to these problems. We also have the researches of Dietzell, Atwater, Strecker, Franck, Wolf, &c. Atwater used a calcined river sand in which he planted peas. These peas were nourished by nutritive matter in solution containing calcium and potassium nitrate in varying proportions. In twenty cases the results gave twelve times more nitrogen than had been present at the start in the seed, or conveyed to it by matter in solution.

Wolf employed a river sand greatly impoverished by washing. In some instances he used no manure, in others he added a nutritive mixture devoid of nitrogen, but containing more or less potassium nitrate. The oats cultivated always yielded less nitrogen than had been supplied them in the seed grain and in the manure, whilst beans, lupins, and clover yielded a large surplus.

Franck used a sandy soil containing humus with 1 per cent. of nitrogen. One portion was left bare and others were sown with lupin and clover. In those portions where the vegetation was rich there was a gain in nitrogen, whilst that portion which had remained unplanted, or where the plant growth was feeble, showed a loss.

Strecker experimented with oats and lupins, and stated that the latter, sown without manure, acquired a remarkable proportion of nitrogen, whereas the oats only showed a loss.

Dietzell, who carried out his experiments in garden earth divided into planted and unplanted allotments, proved a loss of nitrogen in those which had been planted and manured, whilst those left unplanted and unmanured showed an increase.

M. Joulie, a famous French scientist, cultivated buckwheat for two years in a sandy soil, manured and unmanured,

subsequently planting this same soil with clover. In the first period there was no increase in nitrogen, and in the second there was a considerable surplus.

Although the results obtained by these various scientists are distinctly similar, their explanations differ. Dietzell takes no account of free atmospheric nitrogen, and believes that phosphoric acid in solution favours the association in the soil of nitrogen with other substances.

Atwater and Joulie stated the absorption of nitrogen by the Leguminosæ as a fact, but assigned no reason. Franck believed that there exist in the soil two mechanical forces: one tending to release nitrogen from its compounds, the other endeavouring to bring about these combinations. This force is assisted by the presence of plants living in the soil. Wolf's theory was that the humidity in the soil absorbs ammonia, and thus occasions the surplus of nitrogen; but he was astonished that this attracting force favoured the absorption of the nitrogenous element only in the Leguminosæ.

Strecker refused to admit that the Leguminosæ had the power of absorbing additional nitrogen, and considered that it was only a question of amount.

Inquiry into External Causes.

In 1875 M. Berthelot assigned to certain non-nitrogenous organic substances, such as, for instance, cellulose, benzine, turpentine, &c., the property of fixing atmospheric nitrogen when submitted to an electric current.

In 1885, that is to say, ten years later, Berthelot attributed to clay soils, as well as to the micro-organisms they contain, an action on the fixation of nitrogen. In 1886, in a second memoir, he investigated the nature and proportion of the organic matter present in these soils, matter without which the living micro-organisms, with their capacity for fixing atmospheric nitrogen, are unable to exist.

Later on, Berthelot continued his researches on vegetable soils with the aid of plants, and gave his conclusions as

follows: "Upon the whole, in these experiments considerable nitrogen fixation took place. Firstly, in sands and clayey soils, as well as in vegetable soil properly so-called, when I experimented without vegetable matter being present; secondly, both in soil and plant together when vegetable matter was present."

It has thus been distinctly proved that at the period which we have now reached, namely, 1886, or two years before the appearance of the work of Hellriegel and Wilfarth, to whom the honour of suppressing all doubt and controversy was reserved through their remarkable experiments, the fact was already established that these soils, with the micro-organisms they contain, had the faculty of fixing atmospheric nitrogen.

Complete ignorance reigned, however, as to the mode of life of these micro-organisms. They had never been isolated, and consequently had never been seen. The unique power of the Leguminosæ of growing in a soil deprived of nitrogen and of storing up nitrogen in their tissues had not yet been explained, in spite of the fact that botanists had already described the occurrence of nodules on the roots of Leguminosæ.

Woronin, in 1886, was the first to record the innumerable corpuscles, which closely resembled bacilli, present in the protoplasm of the nodule cells, and declared that these bacilli manufactured food for the benefit of the plant as well as for their own. No one ever thought, however, of establishing a relationship between the root nodules and nitrogen fixation.

This discovery was to be made by Hellriegel and Wilfarth in 1888, and we shall analyse their memoir as briefly as possible. Before doing so, however, let us sum up the various conclusions which the authors drew from the researches we have quoted.

First of all they believed that the Leguminosæ could fix both the nitrogen and carbonic acid of the atmosphere; then

it was thought that by reason of their larger foliage and general growth they were better able than the Gramineæ to store up and utilize the small traces of nitrogen existing in combination in the atmosphere.

Further, it was asserted that the powerful root-system, penetrating deep into the soil, was able to draw up nitrogen from the deeper layers, which was inaccessible to other plants.

The fourth theory leads us to believe that the very life of the Leguminosæ involved the building up and preservation of certain nitrogenous combinations.

The final conclusion attributed to the Leguminosæ the unique faculty of assimilating atmospheric nitrogen.

The first and the last theories were refuted by Boussingault, Lawes, Gilbert, Pugh, and others. The second statement was disproved by the experiments of Mayer on wheat and those of Schloesing on tobacco. These scientists proved that the plants mentioned have the faculty of absorbing ammonia by means of their foliage and of assimilating it to a much greater extent than peas and beans.

The theory based on the greater depth tapped by the root-system was no longer tenable after it was proved that oats and barley have roots just as well developed as those of peas.

The fourth hypothesis was the one which found greatest support. Among the supporters of this latter hypothesis we find Heinrich and others stating that the soil has the property of fixing the traces of nitrogen in combination in the air, and it is a matter of general knowledge that dust particles in the atmosphere, and rain as well, always contain a more than negligible amount of ammonia and nitric acid.

Schonbein, Bottcher, Gorup Bezanez, and Uffelman proved that by the evaporation of water, ammonia was converted, at the expense of the primary free atmospheric nitrogen, into nitrous and nitric acid.

Berthelot showed that even the electricity present at the earth's surface, between soil and atmosphere, was able to convert free nitrogen into nitric acid. He further demonstrated that the micro-organisms are able to assimilate the free atmospheric nitrogen and to deposit it in the albumen (perisperm).

Boussingault laid stress on the influence which porous bodies exert on the conversion of the nitrogen present in complex organic compounds, into ammonia, and from ammonia into nitric acid.

Dumas, de Lucas, Gloez, Wolff, Franck, attributed the same faculty to alkalis and alkaline soils. Schloesing, Muntz, Landolt, and others classified bacteria as agents capable of converting organic nitrogen into ammonia and thence into nitric acid.

Although these opinions seemed to confirm, or, at any rate, to lend a semblance of truth to the theory contained in this hypothesis, other scientists, on the other hand, published researches which nullified the earlier conclusions.

Lawes, Gilbert, and Berthelot found that rain-water, draining off in the deeper soil layers, always contains appreciable quantities of nitric acid. Morgen, Dietzell, Schloesing, and Warrington showed that a portion of the nitrogen liberated from nitrogenous organic compounds by their conversion into ammonia and nitric acid, is found either as free nitrogen or as nitrogen protoxide.

Finally, if there exist bacteria which nitrify ammonia, there are others (work of Gayon, Dupetit, Déhérain, and Maquenne) which reduce nitric acid to nitrous acid, to oxides and protoxides of nitrogen, and even to free nitrogen. The nitrified substance in the soil may thus vary under the influence of all sorts of different factors, and the Leguminosæ are unable to prevent certain causes of loss which occasion variations in the richness of the soil. It was in the face of all these hypotheses, these theories and con-

clusions, that Hellriegel undertook the work which was to enlighten us.

Various Researches on Nodules.

The above studies of the power of assimilating atmospheric nitrogen were undertaken simultaneously with the researches on the nodules of the Leguminosæ.

As we have already seen, the roots of the Leguminosæ are characterized by fleshy excrescences which form the root tubercles, or, rather, the nodules. These nodules may vary in form according to the plant sown, but they are fairly constant among individuals of the same species. They are sometimes simply spherical, as in the bean; sometimes oval, as in clover; elliptical in vetchlings; elongated ovoid, conical, and occasionally more or less digitate as well. Certain varieties, such as vetches, for instance, are characterized by numerous nodules formed at nearly every swelling.

Nodules should not be confused with certain galls provoked by eel-worms; these are distinguished by their irregular indentations.

The influence of the conditions under which the plants are grown is an important factor in the formation of nodules, but at the same time they do not act to the same degree on all Leguminosæ. That is the reason why some occasionally lack these structures, while others require altogether abnormal conditions to check their formation.

But what is the nature of these nodules? We should have great difficulty in answering this question had we not the work of M. Mazé, of the Institut Pasteur, to clear up a subject on which scientists were not in agreement. Since we have been able to analyse briefly the works dealing with the faculty of plants for fixing atmospheric nitrogen, we shall now state in a few words the various opinions expressed on the question of the nodules.

In 1687, Malpighi, albeit with some caution, declared them to be galls. Treviranus, in 1853, without admitting

Malpighi's theory, saw no inconsistency between underground habitat and gall formation.

Franck, in 1879, believed that these tubercles were a disease provoked by insects of the name of *Anthomyia;* but Cornu, in 1876, after mistaking galls caused by eel-worms occurring among the nodules, had already realized that the nodules had no relation to these parasites.

Bivona thought they were fungi developed on the roots, while de Candolle and Julasne stated that they were merely morbid tumours, or fleshy knots.

Clos believed their formation to be due to the medium in which the plants were cultivated, the tubercles of Leguminosæ being merely lenticels.

Gasparrini, at Naples, in 1851, considered the swellings on the Leguminosæ to be root tips and called them spongy tubercles owing to their property of rapidly regaining turgidity *in water after having been previously dried.*

De Vries (1877), Tschirch (1887), Van Tieghem and Douliot (1888) regarded the tubercles as a special form of root.

The majority of writers believed in the action of some Cryptogam; notwithstanding the fact that, in 1866 and 1867, Woronin attributed the nodules to the influence of bacteria and called attention to the bacilli which he discovered in the protoplasm and which strongly resembled micrococci.

Professor Vuillemin, of the University of Nancy, in 1888, after an exhaustive investigation of their anatomical characters, declared the root tubercles of the Leguminosæ to be Mycorhizæ, that is to say, roots united symbiotically with a living fungus.

Thomas Jamieson, whom we have already quoted, believed that the tubercles were the scars of wounds provoked by the attacks of fungi. The plant reconstructed its tissues, which would then engulf the fungus and neutralize its effects.

Hellriegel and Wilfarth brought their remarkable work

on the Leguminosæ to a close in a manner which showed that, in their opinion, the nodules contained bacteria.

"The Leguminosæ do not possess of themselves the faculty of assimilating free atmospheric nitrogen; the vital action of the micro-organisms in the soil is absolutely indispensable if this result is to be attained. In order that free atmospheric nitrogen may aid in nourishing the Leguminosæ, the mere presence of lower organisms in the soil is not sufficient; it is further necessary that some should enter into symbiotic union with the plants."

M. Mazé, Technical Director of the Laboratory of Agricultural Chemistry at the Institut Pasteur, published in 1897, in the annals of that institution, a treatise on the microbes in the nodules, which now leaves us with no further doubt as to the existence of bacteria in the root tubercles of the Leguminosæ.

M. Mazé has succeeded in isolating these bacteria, that is to say, in causing them to reproduce. Appended herewith are the conclusions at which he arrived:—

"The bacilli of the Leguminosæ, when placed in a suitable medium corresponding as closely as possible to the natural conditions present in the nodules, grow in remarkable fashion and at the same time discharge their important function of fixing free atmospheric nitrogen.

"Symbiosis is no longer necessary in order to explain the fixation of free atmospheric nitrogen by the microbes of root nodules; this is their special function, and perfectly independent of any influence exerted by the plant. No new force is evolved from the co-operation of these two organisms, the action of which is necessary in order to induce the free nitrogen to enter into combination with organic or organized complexes; and at the same time the hypothesis adopted till now in order to explain the symbiotic mechanism, so clearly expounded by M. Duclaux, remains unimpaired and, further, receives the confirmation of practice. The plant shelters an organism and supplies it with the carbohydrates

and organic nitrogen upon which it lives, and from which, at the same time, it draws the energy necessary to fix the free nitrogen destined, as M. Nobbe says, to be placed in assimilable form at the disposition of the plant.

"To place this organism in a medium devoid of nitrogen in combination is to force it to nourish itself at the expense of atmospheric nitrogen. It must, first of all, ensure its survival, and this it does by multiplying at the expense of the resources stored up in the plant's cotyledons while awaiting the formation of those organs of the plant which enable it to derive its nourishment from the soil and atmosphere.

"The free access of air exerts a most favourable influence on the fixation of nitrogen."

The authority of the writer and the rational arguments arising from his experiments confirm the theory concerning the occurrence of bacteria in the nodules of Leguminosæ.

The works of Mazé followed those of Bréal, Schloesing, Laurent, Beijerinck, and Praznowski.

We shall next see how Hellriegel and Wilfarth arrived at the same conclusion.

The Work of Hellriegel and Wilfarth.

As early as the year 1862, Hellriegel, in collaboration with Drs. Fittbogen, Fruhling, Sorauer, and Marx, undertook, at the Agricultural Station at Dahme, a series of experiments on the Gramineæ and Leguminosæ. They came to the conclusion that the Gramineæ were unable to grow in a soil devoid of nitrogen, once the nitrogen contained in the seed had been exhausted by the plant. Also, whenever these plants were furnished with nitrogenous food their development was normal, whereas in proportion as the nitrogenous diet was diminished so did the relative crop decrease.

Check experiments confirmed the original results, and these scientists concluded that the Gramineæ, being unable to live in soil devoid of nitrogen, did not have the property of fixing atmospheric nitrogen.

Totally different was the case of the Leguminosæ, which, planted in a soil completely devoid of nitrogen, throve well, while peas planted in this same soil the year after followed their normal development. Hellriegel, however, was induced through a few failures to put a stop to his experiments and to study, till 1873, the influence exerted on plant development by each of the various known factors of growth, such as the quality of the seed, the volume of soil, its mechanical structure, the period of sowing, light, heat, air and, finally, moisture.

It was only in 1883, after the founding of the Agricultural Station at Bernburg, that Hellriegel and Wilfarth were able to recommence their researches. The first three years, 1883-1885, were devoted to fresh experiments on the Gramineæ and Leguminosæ. Once more a negative conclusion was obtained as to the power of the Gramineæ to fix atmospheric nitrogen.

Peas showed irregular development, although, as every precaution had been taken as to the nature of the soil and general conditions, the causes of this irregularity could only have been accidental.

These negative results led the scientists to believe that bacteria certainly must play a part in the growth of Leguminosæ, and induced them, in 1886, to undertake experiments in that direction. The results being so conclusive, in 1887 experiments were renewed, and the opinion they had formed was still further confirmed.

Further, Hellriegel's memoir gives us details as to all the experiments conducted on oats and barley, with numerous illustrations of the various methods employed. The value of these experiments is still more evident when it is seen what pains were taken to avoid sources of error.

The primary soil materials employed were a fine quartzose sand, chemically impure and containing other material beside silica.

	Per cent.
Sulphuric acid	0·0052
Lime	0·0080
Magnesia	0·0030
Potash	0·0014
Soda	0·0067
Phosphoric acid (only traces).	

Only distilled water was used for irrigation, and the first third from each distillation was removed owing to the possibility of its containing traces of ammonia. Nutritive solutions were then prepared with this water, and although the results obtained with the Gramineæ were negative, so far as nitrogen fixation was concerned, they none the less furnished a striking illustration of the plant faculty of absorbing mineral salts, and of the influence of these latter on the growth of crops.

Appended is a table giving the yield, in dry matter, for oats and barley raised on solutions respectively rich and poor in this nutritive material :—

	Barley		Oats	
	Rich admixture	Poor admixture	Rich admixture	Poor admixture
Seed ...	13·571	12·676	12·891	11·499
Husks ...	2·015	1·984	1·643	1·392
Straw ...	12·270	9·051	12·119	11·103
	27·856	23·711	26·653	23·994

	Percentage of crude ash		Percentage of pure ash	
	Oats	Barley	Oats	Barley
Seed ...	2·65	1·86	2·62	1·80
Husks ...	9·46	9·15	8·50	7·27
Straw ...	13·24	6·39	12·32	4·38

The greater part of the mineral matter is seen to accumulate in the straw.

As we have already mentioned, the irregularities occurring in the previous experiments led Hellriegel to believe

that bacteria played an important part in the fixation of atmospheric nitrogen by the Leguminosæ.

In order to test this theory, Hellriegel used quartzose sand as the plant medium, and carried out a number of comparative tests, using for watering purposes infusions of soil prepared under certain conditions. The micro-organisms being present in vast numbers in the soils taken a simple solution was sure to contain some. After having calcined the sand, the author filled glass vessels with it and planted peas in them. Some were watered with distilled water, others with a soil solution, and the remainder with a soil solution which had been raised to boiling point. The object of this latter operation was to test the efficacy of the soil solution, to ascertain, that is, whether the bacteria would have any effect, as they are unable to withstand a temperature of more than 60° to 70° C.

The results were thoroughly conclusive, and the plants watered with the soil solution continued to grow, whilst the others withered as soon as the nitrogen of the seed was exhausted.

The following tables show the results obtained, and demonstrate, without a shadow of doubt, the influence of bacteria on the formation of nodules and their faculty of fixing atmospheric nitrogen.

EXPERIMENTS TO SHOW THE INFLUENCE OF A SOIL INFUSION ON THE ACQUISITION OF NITROGEN.

Years	Numbers of the vessels	Nitrogen supplied in nitrate of lime	Dry matter furnished by the aerial portion	Balance of nitrogen
1887 Without soil infusion	254	0·056	2·838	− 0·050
	255	0·056	2·927	− 0·049
	256	0·112	6·223	− 0·064
	257	0·112	6·858	− 0·064
1887 With infusion of sandy soil	258	0·056	11·936	+ 0·105
	259	0·056	15·324	+ 0·169
	260	0·112	11·037	+ 0·042
	261	0·112	17·077	+ 0·183
	244	0·000	16·864	+ 0·326
	245	0·000	18·190	+ 0·373
	248	0·000	11·686	+ 0·330
	249	0·000	16·411	+ 0·421

INFLUENCE OF A BOILED SOIL INFUSION.

Years	Numbers of the vessels	Nitrogen supplied in nitrate of lime	Dry matter urnished by aerial portion	Nitrogen recovered in the whole plant
1887 In sterilized soil	322	0·000	0·779	0·013
	323	0·000	0·774	0·013
	324	0·000	0·928	0·014
	356	0·007	1·339	0·013
	357	0·007	1·308	0·013
	358	0·007	1·265	0·014
1887 In sterilized soil to which a boiled soil infusion had been added	328	0·000	0·898	0·015
	329	0·000	0·842	0·014
	330	0·000	0·922	0·015
	359	0·007	1·044	0·018
	360	0·007	1·071	0·016
	361	0·007	1·155	0·016

The authors concluded from these observations that the accumulation of nitrogen in the Leguminosæ is the work of micro-organisms; indeed, thanks to the foregoing experiments, we are forced to acknowledge that this assimilation rests on a symbiotic relationship of these plants, which exerts a great influence on their vital functions.

The experiments of Berthelot showed that an uncultivated soil possessing certain qualities favourable to the development of bacteria was able to add to and keep its stock of nitrogen, while those of Franck proved that similar increase might result from the work of algæ and mosses. While giving full weight to these considerations, Hellriegel cannot think that they are sufficient to clear up the question of the assimilation of nitrogen in his experiments.

For instance, it would be difficult to explain how peas are able to assimilate this nitrogen, whereas oats and barley, with a period of growth equally long, are unable to derive profit from this source. Again, how can one explain why the addition of a small dose of soil infusion exerted no influence whatever on the growth of lupins and serradellas, whereas the same quantity assisted that of peas? It is true, the difference in species might be invoked in order to explain their unequal capacity to utilize this nitrogen, but such an assertion, say the authors, is not founded on any known fact, nor is it confirmed by practice.

All these phenomena, and others still more complex, are in no way mysterious if it be admitted that certain higher plants are in intimate relationship with micro-organisms which collect nitrogen and thus perform this useful work.

Without denying the work of bacteria, algæ and fungi, which fix nitrogen, Hellriegel wishes simply to demonstrate that the gain in nitrogen cannot proceed from this source alone. Indeed, in his experiments, the fact that lupins and serradellas were furnished with large quantities of algæ and mosses of all kinds did not prevent them from perishing of nitrogen hunger.

Certain anomalies which arose during the course of trial growths in 1887 led the authors to think that sterilization had played an important part in connection with the appearance of mosses and algæ on the sides of the vessels containing the earth. In those vessels which had been sterilized this growth appeared only after the lapse of several weeks, and had no effect on lupins and serradellas, while it accelerated the growth of peas. They concluded that the same soil infusion had different actions on lupins and peas, and explained these phenomena as follows.

If it be true that the growth of Leguminosæ in soils devoid of nitrogen is the result of this symbiosis with micro-organisms, it must be admitted that each leguminous plant has its own particular species of such micro-organisms, and as these different species of bacteria are not equally distributed throughout all soils, we have the reason why the same soil infusion does not act in equal manner on both lupins and peas. Since these variations cannot arise from the physical or chemical properties of the soil, they must be due to differences in the bacterial population.

Hellriegel and Wilfarth expressed the opinion, before a meeting of German naturalists, that the tubercles of Leguminosæ played an important part in assimilating nitrogen. Finding this opinion subjected to a considerable amount of criticism, they undertook a series of experiments which

showed they were perfectly correct, and from which they drew the following conclusions :—

(1) In a sterilized medium without nitrogen content the Leguminosæ show no tubercles and the plants perish.

(2) In a medium which is unsterilized, but devoid of nitrogen, tubercles are present and the plants do not wither.

(3) In a sterilized soil containing nitrates the Leguminosæ show no tubercles but survive notwithstanding.

(4) In an unsterilized soil containing nitrogen, nodules are to be observed and the growth is perfect.

The following table shows facts relating to the production of tubercles under different cultural circumstances and also indicates the extent of assimilation of nitrogen in each case :—

EXPERIMENTS TO SHOW THE INFLUENCE OF BACTERIA ON THE FORMATION OF ROOT NODULES.

Numbers of the vessels	Dry matter furnished by the whole plant	Gain in nitrogen during growth	Tubercles formed on the roots
			In sterilized sand without addition of nitrogen.
242	0·092	Nil	Nil
243	0·063	,,	,,
246	0·084	,,	,,
247	0·109	,,	,,
266	0·135	,,	,,
267	0·092	,,	,,
			In sand provided with soil infusion without addition of nitrogen.
244	16·864	+ 0·348	Numerous tubercles; large and small, old and recent, on all the roots.
245	18·190	+ 0·395	As above, somewhat stronger and more numerous perhaps.
248	11·686	+ 0·352	Numerous tubercles; the older kind a trifle more numerous.
249	16·411	+ 0·443	
250	12·530	+ 0·249	
251	9·409	+ 0·202	
268	17·370	+ 0·386	A number of large protuberances, for the most part still firm and full.
269	13·491	+ 0·287	Numerous others more recent on the secondary roots.

No fact can be cited from among these observations to support the theory which regards the tubercles as storehouses for nitrogenous nutriment. This theory is based on the fact of the nodules, like the roots and leaves,

becoming empty at the period of maturity. It further rests on the fact that the tubercles are more abundant in a soil poor in nitrogen, while their development is restricted when the soil is rich in that element.

It is difficult to grasp the idea of storehouses retaining quantities of nutriment for which the plant is hungering, while they are empty when the nutriment is most plentiful.

EXPERIMENTS TO SHOW THE INFLUENCE OF BACTERIA ON THE FORMATION OF NODULES.

Numbers of the vessels	Nitrogen supplied in the form of nitrate	Dry matter furnished by the whole plant	Gain in nitrogen during growth	Tubercles formed on the roots
				In sterilized sand with addition of nitrate.
262	0·007	0·269	−0·005	Nil
263	0·007	0·272	−0·004	,,
264	0·007	0·316	−0·000	,,
265	0·007	0·297	−0·000	,,
254	0·056	2·838	−0·028	,,
255	0·056	2·927	−0·027	,,
256	0·112	6·223	−0·042	,,
257	0·112	6·858	−0·042	,,
270	0·112	6·077	−0·042	,,
271	0·112	6·837	−0·046	,,
				In sand provided with soil infusion and with addition of nitrate.
258	0·056	11·936	+0·127	Numerous tubercles, of which many were old and some already empty.
259	0·056	15·324	+0·191	As above, but fewer old tubercles.
260	0·112	11·037	+0·064	A fair number of old tubercles, but nearly all firm; a large number of very small protuberances on the beard.
261	0·112	17·077	+0·205	

From the mass of observations recorded by Hellriegel and Wilfarth there was general agreement in regarding these nodules as means of plant nourishment, and this induced the authors to publish the following statements:—

(1) The formation of nodules and the plant growth are independent of each other; plants have been shown to grow in normal fashion without any nodules.

(2) This formation is independent of nitrogen assimi-

lation and plants have absorbed nitrates when no nodules were present.

(3) This formation occurred wherever addition to sterilized soils was made by a fresh infusion of sandy earth in cultivation. No formation took place when the infusion had been sterilized, and from this we can deduce that the formation is due to the presence in the soil of an organized ferment.

(4) The formation of nodules was accompanied by a gain in nitrogen, occurring during growth, which could not be attributed to the original nitrogen content of the soil.

The following experiment confirmed the two scientists' statements :—

Eight vessels received an equal amount of nitrogen. The first four were sterilized and nothing was added. The plants in these did not grow beyond a limit corresponding to the original amount of nitrogen placed at their disposal.

The four remaining vessels received the same amount of nitrates with the addition of an earthy infusion. The plants in these grew normally and showed a gain in nitrogen exceeding the amount in the nitrates, while the total amount of dry matter was by no means in strict relation to the nitrogen content of the soil.

Franck carried out an experiment to refute this, but it was defective, and did not prevent Hellriegel and Wilfarth from asserting that the formation of tubercles rested on the faculty these plants have of deriving nitrogen from other sources than those afforded by nitrates or other nitrogenous compounds in the soil.

These assertions remained uncontradicted by any experiment, not even by those of Rantemberg and Kuhn showing that Leguminosæ which had been grown in water were provided with nodules which in no way increased their gain in nitrogen.

Indeed, the possession of assimilating organs does not necessarily ensure luxuriant growth in the plant, for they

may be hindered in their functions by certain specific causes which are, so it happens, encountered in growth in the water.

To bring this brief account of Hellriegel and Wilfarth's work to a close, we will summarize their final arguments, based on the life of the plant, proving that the nodules can in no way be regarded as receptacles for reserve food supply.

The growth cycle may be divided into three phases—germination, growth, maturity. During germination the plant develops aerial and subterranean structures by drawing the necessary materials from its reserves, that is to say, from the cotyledons.

During growth an active assimilation of nutriment from external surroundings takes place. A general growth of the organs occurs, and the chief mass of the plant is formed.

In the third phase the organs of fructification appear. Assimilation diminishes and eventually ceases, and the whole of the elements in leaves and roots are employed in nourishing the plant till the time of its maturity.

These three phases, however, have their periods of transition, and the progress from one to another is a gradual one. If the plant is situated in rich soil, the third period is postponed; assimilation is prolonged and the plant may be said never to reach maturity. Should the soil be poor, it is the second phase which changes; the plant is unable to assimilate and lives on its reserves, in consequence the organs are distorted and sickly and often fructification does not take place. According to the authors of these researches, it is this lack of assimilation which is the cause of inanition.

It was proved that a soil infusion had no effect on cereals living in a sterilized medium devoid of nitrogen, whilst it often influenced Leguminosæ. These latter, however, often experienced a period of inanition, even when the soil extract was incorporated before sowing. Germination having taken its normal course, those plants which had been treated with

the infusion ceased growing and their organs faded. This state of affairs only lasted a few days, the actual period depending on the ultimate reserves in the seed. Then, all at once, the influence of the infusion began to make itself felt. The organs, stunted but not yet withered, took a fresh lease of life, the chlorophyll was reformed, fresh leaves were seen to sprout, and the plant, entering the assimilatory stage, throve anew.

Hellriegel and Wilfarth have endeavoured to prove that it is during the period of inanition and before assimilation and consequent growth that the nodules are formed. They showed on trial plants that the roots never bore nodules during germination, and at the beginning of the period of inanition; they only appeared in the final stage when the leaves were becoming green.

The nodules then cannot serve as storehouses, for it is impossible to explain how a plant, with growth hindered by lack of food, can, notwithstanding, find food for storage purposes. At the same time, we have, in the action of the soil infusion, an additional proof of the co-operation of an external agent, and this latter can only be the micro-organisms of the earth.

THOMAS JAMIESON.

Although the theory of Hellriegel and Wilfarth is to-day almost universally accepted, a Scotch scientist, Thomas Jamieson, Director of the Agricultural Station at Aberdeen, after thirty years of stubborn experimental work, has come to an entirely different conclusion as to the method by which the Leguminosæ fix atmospheric nitrogen. As we do not wish to pass over any work dealing with this problem we shall now give an account of Jamieson's theories and experiments.

Firstly, the author aims at proving that the formation of nodules on the roots of Leguminosæ is the effect of the attacks of a fungus perfectly incapable of fixing atmospheric

nitrogen. In support of this Jamieson lays stress on the fact that the upholders of bacterial theories have never been able to prove the presence of bacteria in the nodules; as a matter of fact, no observer who has paid attention to this question has found anything more than fungi, fungoid hyphæ, sporangia or spores.

The fact that the Leguminosæ are more subject to the attacks of fungi causes Jamieson no surprise. Greedy for nitrogen, the fungi are more likely to be attracted by the Leguminosæ, whose roots afford nourishment rich in that element. The nodules are only formed to engulf the fungus, to render it inactive, and to heal the wound.

The author further proves that fungi, being devoid of chlorophyll, are in all probability unable to absorb nitrogen, and since the bacteria themselves are under the same disadvantage, we are justified in concluding that they too are unable to perform this function.

In proof of this, Jamieson quotes the case of turnip fields ravaged by a particular fungus, and takes as his authority Professor Trail, of Aberdeen University, who, after having made a special study of pathogenic formations, asserts that the action of a fungus is sufficient not only to cause the formation of tubercles of this kind, but further to excite in the plant a reaction involving a certain richness in composition in the part attacked.

According to Jamieson, therefore, the formation of nodules is nothing remarkable; it is merely one case among a number of analogous ones.

Another fact which the author brings forward in support of his thesis is the capacity of all plants, except those devoid of green matter, to fix atmospheric nitrogen by means of certain aerial organs. Algæ which are composed of simple loose green cells fix atmospheric nitrogen. Franck's experiments show that 25 to 36 per cent. of the total nitrogen content of these plants is absorbed by the cells containing green matter.

Among higher plants there are very divergent types of leaf structure. In some a thin epidermis separates the cells from the surrounding air; in others there is a fibrous investment and the cells are very crowded. It is extremely probable that these differences have an enormous influence on the power of absorbing nitrogen.

Among all members of the family of the Leguminosæ the leaves are large and soft. Their cells are pierced by apertures or stomata which are thought to serve merely for transpiration. But why should not these cells be able to absorb atmospheric nitrogen as well as carbonic acid? Agriculturists know that a leguminous plant, and the turnip also, need only a very small initial quantity of nitrogen as compared with that yielded by the crop. The author aims at drawing an analogy between the large leaves of the turnip, with their thin epidermis, and those of the Leguminosæ, which, according to him, are all large and soft.

Cereals, on the other hand, which do not possess this faculty of fixing atmospheric nitrogen to the same degree as the Leguminosæ, are very sensitive to an addition of nitrogenous manure, and their yield is thereby increased. This is easily explained if a leaf of a cereal or of a pasture grass be examined; the tissues are crowded, have but little access to the air, and, further, are covered by a fibrous layer.

After a series of analyses and various experiments, the author carried out numerous researches on the microscopic structure of plant leaves, from which he came to the following conclusions:—

(1) All plants, at a particular period of their growth, give rise to certain specialized hairs, which produce albumen. (He revealed this albumen by means of three reagents: iodine, sulphates of copper and potassium, nitrate of mercury, &c.)

(2) All these specialized hairs are stuffed at their upper ends with albumen, which, after a certain time, they allow

to drain into the lower portions, and thence to all parts of the leaf.

(3) These albumen-producing hairs are sometimes situated on the petiole, and often on every surface of the leaf, though chiefly along the edges.

If the formation and discharge of the albumen are to be thoroughly understood, it is often necessary, in the case of certain plants, to examine the seedling. It is not likely that there is any essential difference in structure between the long and short hairs, for the production or non-production of albumen is due to the presence of green matter in some and its absence in others. The presence of green matter depends on the amount of vigour present in the hair at the start. The position which the hair occupies on the plant determines the production of green matter, which varies in quantity according to the flow of sap.

The fact that nature apparently provides plants with special means of absorbing nitrogen is in no way remarkable to Jamieson, in view of the sluggishness of nitrogen. He further finds it quite rational that this absorption should be restricted to certain of the youngest organs, since from early youth onwards the plant needs practically the whole of its nitrogen in order to construct its tissues.

The existence of specialized albumen-producing hairs on the young shoot and on the investment of the young flower bud is thus an interesting and useful example of Nature's way of adapting means to an end. It is just as difficult to explain by what processes the chlorophyll converts nitrogen into organic matter, as to demonstrate how leaves break down carbonic acid.

Jamieson concludes his work by saying he cannot affirm the green matter in the leaves to be the same as that in the hairs, and considers he has brought sufficient proof to gain acceptance for his theories.

Whatever the value of the researches of the Director of the Aberdeen Agricultural Station may be, the theories of

Hellriegel alone will find acceptance by reason of their confirmation in practice. At the same time, it would be unwise to be too exclusive and to reject Jamieson's arguments *a priori*. M. Henry, Professor of Forestry at Nancy, shares this opinion, for a number of points in Jamieson's researches have been confirmed by experiments in Hungary.

Dr. Géza Zemplen and M. Julius Roth, of the Central Station for Research in Forestry at Selmec Banya, in Hungary, have recently published their researches in the bulletin of this station.

"It is of particular interest to the forester," say these Hungarian scientists, "that Jamieson should have already undertaken researches on various trees of our woods. As a matter of fact, he does not consider forest trees to be particularly suitable for this kind of research; but, in spite of that, he has found special organs for the fixation of nitrogen in the common maple, linden, &c.

"Following Jamieson's researches we have endeavoured to find these organs for assimilating nitrogen in our own indigenous trees as well as in a few exotic species. Our researches confirm the views of the Scotch scientist and at the same time extend the evidence for them, as we have found these structures in a number of genera which he had not examined.

"Our researches prove that our forest trees, when at the height of their activity, possess organs analogous to those found by Jamieson, serving, perhaps, divers purposes, but having their real, primary object in the direct absorption of atmospheric nitrogen."

There will be no need to dwell any further on the paper published by the Directors of the stations at Selmec Banya, as the passages quoted are sufficient to show that these gentlemen are in complete agreement with Jamieson. Further, accurate notes made by the two scientists on various plants prove the occurrence of an increase in nitrogen which can only have come from the air.

In view of the confirmation which this theory has just, in some sort, received from Hungary, M. Henry is of the opinion that it is not one to be dismissed without discussion. Consequently, in order to put Jamieson's theory on a firm foundation, he determined to cultivate trial plants in a limited atmosphere of known volume, and absolutely devoid of nitrates and of ammonia; just as MM. Schloesing and Laurent did with peas and tobacco. Analysis of the gases showed that after three months' growth a certain volume of nitrogen had disappeared, having been fixed by the plants or soil, and an analysis of the plants showed that precisely the corresponding amount of nitrogen had been gained.

It is in this vein that M. Henry concludes his criticism, and he adds that if the plants possessing these nitrogen-fixing organs give similar results, the absorption of primary atmospheric nitrogen will be a proved fact. Till then we will take as our foundation in determining the physiological character of the Leguminosæ the work of Hellriegel and Wilfarth. This decision is rendered easy by the numerous researches of various scientists on the formation of root nodules, as well as on the evolution of races among the bacteria of the Leguminosæ.

Formation of Root Nodules.

Like all other bacteria, the bacteria found in root nodules are present in the atmosphere, in water, and in the soil. They appear to be attracted by carbohydrates in the piliferous region of the roots. They enter through hair cells, reproduce, and spread along a sort of channel as far as the cells of the cortex. The cells divide and viscous matter is secreted by the bacteria, which is disseminated through a series of small channels of infection. This viscous matter, a product of bacterial katabolism, is carried along by the sap and can then be assimilated. Such is the explanation put forward by M. Kayser.

The microbe acts as a parasite so long as the tubercle is incomplete, for the bacterium can only fix atmospheric nitrogen after its transformation into bacteroids, *i.e.*, after dividing to form branching filaments. Consequently during this transformation the plant must suffer, the bacterium growing at its expense. In proportion as the nodule increases in size so its richness in nitrogen increases; thus, generally speaking, we find the greatest nitrogen content towards the period of flowering and before the formation of the fruit.

We have had the opportunity of observing, says M. Kayser, that Leguminosæ growing under certain conditions do not produce nodules. The explanation of this can be found in conclusions enumerated in certain works showing that the plant does not form nodules when it has another source of nitrogen at its disposal, or when the bacterium present is not adapted to the particular leguminous plant. This further explains how the plant which has another source of nitrogen is able to resist infection.

Woltmann asserts that humus, lime, &c., favour the development of the root tubercles. Perrotti attributes their growth and the increased crop to manganese, nickel, and cobalt.

Nobbe and Hiltner have drawn attention to another factor, the relative virulence of the microbe. This virulence varies in intensity and depends on the relative ease with which the microbe is able to invade the root and to form its colonies. It is on this that the proportion of nitrogen fixed depends, for every kind of Leguminosæ offers more or less resistance to the invasion of bacteria.

There are, however, other possibilities, and M. Kayser, in his "Agricultural Microbiology," writes as follows:—

"Firstly, there are some bacteria which are incapable of penetrating the root hairs through their inability to secrete the diastase necessary to convert the hair membrane into viscous matter.

"Secondly, there are others which may enter the root hairs, but are then at once engulfed by the cell nuclei, with the result that the nodules are of small size or even completely lacking.

"Thirdly, the bacteria are fairly virulent in their action and entail the formation of nodules of varying size, secretion of viscous matter, and fixation of nitrogen; once the plant is invaded, it can successfully resist the attacks of all less virulent species—it has been rendered immune.

The nodules formed on the lateral roots contain bacteria of greater virulence than those in the primary root. This may be explained by supposing a progressive intensification of the microbe's activity.

Finally, we may admit that nodules are formed when bacteria penetrate the root hairs; the bacteria are nourished by carbohydrates and they secrete a viscous matter rich in nitrogen and only perform their functions after conversion into bacteroids. The quantity of bacteroids varies according to the amount of sustenance in the particular medium.

Mechanism of Free Nitrogen Assimilation.

What is the mechanism by which free nitrogen is assimilated?

According to M. Kayser, this arrangement is founded upon the exchanges which take place between bacterium and plant. The former receives nourishment from the plant in the form of carbohydrates, and in exchange returns it the nitrogenous substance, through the intermediary of the nitrogen of the air. The plant thus profits only through the products of bacterial katabolism. The bacteria are capable of replacing the nitrogen required by the plants only after their conversion into bacteroids; and this is the reason why the mere presence of nodules does not enable us to say that the association is necessarily a profitable one for the plant.

The culture of these bacteria in a free state in mineral media has enabled us to grasp better the phenomenon of nitrogen assimilation. Mazé stated that, whenever nitrogen assimilation took place, the liquid cultural medium became more or less viscid. This is a characteristic of assimilation, but the leguminous plant, by appropriating the bacterial product for its own use, caused the viscid matter to disappear as fast as it was produced. These experiments have been confirmed by Buchanan and Greig Smith.

M. Kayser sums up as follows:—

"Fixation of free nitrogen in organic compounds and formation of albuminoid matter are possible only when there is accompanying destruction of substances containing carbon."

The Leguminosæ are all the more able to absorb the contents of the nodules in view of the origin of the nodules from the pericycle of the primary root, either opposite or at each side of the wood bundles. The whole of the nitrogenous bacterial product is absorbed by the Leguminosæ; following a check in the growth of the plants in question the bacterial action gradually ceases.

These bacteria, or a portion at least, return to the soil and thus perpetuate their species. Nothing is known of the form they take in the soil nor of their spores; the isolation of the bacteria of the Leguminosæ with the help of soil solutions has never been satisfactorily accomplished.

Judging from the whole of the experiments, Kayser thinks the fact that the bacteria at first live at the expense of the plant is well established. It is this period between the moment when the bacterium penetrates the root hair and its conversion into bacteroids that is the cause of the familiar period of sickness in the Leguminosæ which lasts until the formation of nodules is complete. Thenceforward it is the plant's turn to live on the bacteria, for by that time the bacteria have been converted into bacteroids and have thereupon acquired the faculty of fixing nitrogen.

These bacteroids may be dissolved by ferments secreted by the plants, and may even injure the plant should they attain abnormal proportions.

The plant thus makes use of the products of the bacteroids up to a certain point of its growth. The action of the latter diminishes at the period of fructification and eventually ceases. The bacteroids may revert to their original condition.

Formation of Races of Bacteria belonging to the Leguminosæ.

In view of these facts the question now arises whether special races of bacteria are evolved belonging to different Leguminosæ. Opinion is divided.

Beijerinck shows that each of the Leguminosæ possesses corpuscles of distinctly different appearance: the dimensions vary and their form is more or less branched. Should one of the Leguminosæ be injected with strange bacteria modifications ensue which cause a variation from the original type in the bacteria introduced. Laurent questions whether these are not mere varieties.

Mazé divided the bacteria into two great classes: bacteria which are "calcophile," and bacteria which are "calcophobe," *i.e.*, adapted to alkaline and acid conditions in the soil.

Hiltner and Stormer split them into two groups: *Rhizobium radicicola* and *R. beijerinckii.*

These classifications are by no means accepted by all scientists. Some hold that the bacteria arise from a single species, *Pseudomonas radicicola*, and merely show adaptative race-differences. Others, such as Hiltner, believe that the advantages accruing from culture of the Leguminosæ are the result of the action exerted by their roots round about. The bacteria are in close relation with these roots and convert soluble into insoluble nitrogen.

Beijerinck, in 1890, showed that *Bacillus radicicola* assimilated nitrates, and this property has since been assigned to Azotobacters as well. This conversion of nitrates and other soluble nitrogenous compounds into insoluble compounds provides a stimulus and favours the fixation of atmospheric nitrogen.

In these circumstances the Leguminosæ serve a double object in agriculture; they do not merely fix atmospheric nitrogen, but also favour the same function in bacteria.

Such then are the theories derived from the various phenomena. Should they be confirmed, our ideas and knowledge of soil fertility will develop. In fact, the American theories on toxins accumulated in the soil by plant growth have already altered the old line of research, and there seems to be no *prima facie* reason why this doctrine should not be confirmed when one considers that the Leguminosæ are incapable of yielding the same crop when cultivated continuously in the same soil. Is it impoverishment of the soil; is it a degeneration of the particular bacteria associated with the various Leguminosæ; or is it the accumulation of the toxins they produce? All these three may be contributory causes, but it is impossible at present to say which predominates. What is likely is the fact that in the soil, which Berthelot has designated as a "living world," there is doubtless a perpetual struggle between the various bacteria, and, should it be a harmful species which gains the upper hand, the good species disappear.

As regards the evolution of special races of bacteria, there are thus grounds for believing in the existence of numerous varieties more or less adapted to certain plants and to certain environments.

We shall content ourselves with a mention of the theory of Bonéma and Thiel on the assimilation of nitrogen by plants through oxidation of free nitrogen by ferric hydrate.

Researches have also been made on the influence of sugar. This carbohydrate appears to have the property of

increasing the activity of certain bacteria, such as *Azotobacter chroococcum*. A number of successful experiments have been carried out on soils treated with molasses spread over fields in certain conditions.

In Mauritius this method has been in use for years and has given surprising results quite incapable of being explained by the presence of mineral salts in the molasses. The treatment, however, is somewhat different, consisting as it does in simply spreading the molasses in the trenches or between the rows. The modern planter regards molasses as a valuable aid in his farming.

Artificial Inoculation of Soils.

The recognition of the power of the bacteria in the Leguminosæ to fix atmospheric nitrogen led a number of investigators to experiment on the artificial inoculation of soils.

About the year 1888, Dr. Salfeld, one of the working directors of the Peat Station at Ems, was the first to investigate the action of inoculated bacteria on previously sterile peats. Dr. Salfeld's method was to spread from one to four thousand kilos of earth taken from a field in which Leguminosæ had been cultivated. The results were excellent and numerous applications were made of this method.

M. Grandeau says that one of his friends, the Count of San Bernardo, acting on his advice, succeeded in establishing sulla on his estate in Andalusia by importing soil direct from the Algerian sulla prairies.

In Sweden, in the Flahult cultures, at the Agricultural Station at Aas, and at the station of Lyngby, near Copenhagen, a number of most satisfactory trials of the Salfeld method have been made. In spite of the value of the method, however, it is most expensive in practice, owing to the necessity for conveying huge loads of soil from one point to another no small distance away. It is this

difficulty which suggested the preparation of pure cultures of bacteria. The first attempt at artificial cultures was made by Nobbe and Hiltner and put on the market in 1890 under the name of *nitragine*. This *nitragine* was composed of a mixture of germs collected from various species of Leguminosæ in order that it might meet a number of different requirements, but the trials made were inconclusive.

Hiltner prepared other more virulent cultures. Until 1898 they were cultivated on gelatine by the Institute of Agricultural Botany at Munich, and afterwards by Dr. Kuhn's Laboratory of Biochemistry. The preparation is to-day sold in bottles for treating from about one-half to two acres.

The Swedish stations have carried out trials with these products and have always found them to be inferior to the method of inoculation by actual soil.

Moore, of Washington, has made a preparation of what is termed *nitro-culture*. In experiments on a large scale this product was found to evaporate rapidly and to lose its power.

Professor Bottomley, of London, manufactured a similar kind of mixture which is known to the trade as *nitro-bacterine*.

M. de Feilitzen has carried out numerous experiments at Flahult and the experimental station of Jonkoping with *nitragine*, *nitro-bacterine*, and inoculation by actual soil.

M. Grandeau, who has commented on these experiments in the paper *L'Agriculture Pratique*, gives the following figures for the resulting crops:—

Check plot, not inoculated	8,700 kilos.
Plot inoculated with nitro-bacterine	7,100 ,,
,, ,, nitragine	5,600 ,,
,, ,, soil	43,700 ,,

The yields were thus lower where the two preparations of bacteria were employed.

M. Grandeau also calls our attention to the fact that

the soil employed for the inoculation of bacteria had never borne lupins, and this leads him to say that "the foregoing facts do not seem to accord with the opinion of certain investigators. It is known that a number of bacteriologists admit the specificness of bacteria for different Leguminosæ; according to them each of the members of this large family requires the presence of a special bacterium. The question is far from being definitely settled; it is probable that these micro-organisms, under conditions of which we have at present insufficient knowledge, have the faculty of adapting themselves, by undergoing certain changes, to the nitrogenous nourishment of different Leguminosæ. Possibly it is to some phenomenon of this kind that we must attribute, at Flahult, the influence of the bacteria from peas on the development of lupins. There are still a number of points to be cleared up in this direction."

Apart from experiments at Scandinavian stations, other experiments have been carried out with *nitragine* in France by M. Schribaux in 1896, and by MM. Dickson and Malpeaux in 1897.

Harrison, Edwards, and Barlow obtained, in Canada, as did also their French colleagues, very satisfactory results with *nitragine;* Kellermann and Robinson, in the United States, and Gerlach and Vogel, in Germany, are also satisfied with the use they have made of it.

Another discovery which also aroused a great deal of interest was that of M. Caron, who, after isolating a bacterium from a lucerne, noticed it had the property of rendering the nitrogenous matter in the soil more assimilable. Attempts were made to identify it by comparing it with known species, such as *Bacillus mycoides*, *B. subtilis*, &c. . . . Professor Stoklasa considers the bacterium *Clostridium pasteurianum* has the faculty of fixing nitrogen.

The use of the preparation known as *alinite* was unsuccessful and its manufacture was abandoned.

Beijerinck, Gerlach, and Vogel had no success at all with the sowing of *Azotobacters,* although Professor Hall, of Rothamsted, made some encouraging observations. The only result obtained by Koch was with *Azotobacter chroococcum,* which fixed nitrogen in presence of repeated doses of sugar in small quantities.

From all these experiments we may apparently draw the conclusion that all these bacteria are able to exist in the soil, but that it is the conditions for reproduction which are unfavourable. All farming operations, such as draining, ploughing, loosening the soil in various ways, or any other methods which tend to favour the development of these micro-organisms, will increase soil fertility considerably more than any possible kinds of artificial inoculations. The method of treatment by actual soil appears to be the only one which has a marked effect, but it will always be difficult in practice if the two places concerned are widely separated.

In Mauritius, where the majority of Leguminosæ do well, there is especial need to use them as much as possible for ploughing in, and occasionally for seed.

CHAPTER III.

DESCRIPTION OF VARIOUS LEGUMINOUS PLANTS OF AGRICULTURAL VALUE.

ARACHIS HYPOGÆA (PEA-NUT).

ORIGIN.—*Arachis hypogæa*, the scientific name for the pea-nut, is derived from the Greek *a*, privative, and *rachis*, a branch. It was discovered in Northern America, and is generally believed to be a native of Brazil. M. Marcel Dubard, in a treatise on the origin of the pea-nut, in the *Bulletin du Muséum d'histoire naturelle*, 1906, p. 340, draws attention to the name of "manteiga," or its abbreviation "tiga," by which this plant is still known to the Mandigans as far as the borders of Kong, and whose form ("manteiga" is the Portuguese word for butter) distinctly points to the Portuguese as being originally responsible for its propagation. From this it may be inferred that the first seeds came from Brazil.

The plant spread very rapidly and soon reached the remaining countries of America. Apparently, according to M. M. Dubard, it was first introduced into Peru, and thence into Mexico. From Mexico, towards the beginning of the eighteenth century, the pea-nut made its appearance in France and was cultivated in the Botanical Gardens at Montpellier; later on, towards the end of the same century, it was grown in Spain by Don Ulloa, Archbishop of Valencia, who obtained the seeds from America.

It is to be remarked, however, that the pea-nut was grown in Spain towards 1790, and in Cossigny's work, published in 1802, *Moyens d'Amélioration des Colonies*, we learn that it was the citizen Méchain, Préfet des Landes, in France, who obtained it from Spain and cultivated it in the South of France.

Some time later citizen Tessier, a member of the Institut National, and of the Société libre d'Agriculture of the Department of the Seine, made the members of the Agricultural Society a gift of oil obtained from the pea-nut plants of the *Landes*, and at a banquet given to the members this oil was voted excellent, being, in the opinion of some, equal to the best olive oil that the town of Aix could produce. Cossigny, who took part in the banquet, adds: "After having tasted it with both fish and salad I am able to endorse their opinion."

According to this last piece of evidence the pea-nut, therefore, seems to have been first introduced into Spain.

The original plants which were carried from Brazil into other countries underwent certain modifications, so that it was believed that such and such a variety arose in such and such a country. In 1519-1521, the Magellan Expedition, which opened up to the Spaniards the route to the Far East by way of the Pacific, left them masters of the Moluccas and Philippines, where they introduced the Peruvian form. According to M. Dubard, it is thence that it spread to Japan, to the Sunda Islands, Malacca, Indo-China, the whole of Southern Asia, and Madagascar.

In the opinion of some, the Mauritian variety is derived from Mozambique. This lacks confirmation, but all the known facts point to Bourbon and Mauritius having obtained their seed from Africa, or even Madagascar.

Cossigny says: "The ground-nut has been grown for some considerable time in the Isle of France and Réunion; it was obtained from Madagascar, where this plant is indigenous. The same species is also grown in India. The fruit of the latter is somewhat smaller than that of the Brazilian species, but the shell, which is of the same friable character, is less thick, rougher, and the straw colour is darker. In these islands are found pods containing three or even four seeds, whereas all the original Brazilian species only have one, or at most two."

ARACHIS HYPOGÆA (PEA-NUT)

The pea-nut, *Arachis hypogæa*, is also known as the ground-nut or monkey-nut. The Peruvians called it *ynchi*, the Spanish *mondubi* and later *cacahuete*. M. Dubard believes that the Spanish name *cacahuete* is merely a corruption of the Mexican term.

GEOGRAPHICAL DISTRIBUTION.—At the present day *Arachis hypogæa* is a plant with a very wide distribution throughout tropical and equatorial regions. Its importance varies from country to country. *In Asia:* India, Indo-China, Japan. *In Oceania:* the Island of Java. *In America:* North Carolina, Virginia, Mexico, the Antilles, Jamaica, Curaçao, Brazil, Argentine. *In Africa:* West Coast, Mozambique, Madagascar, Egypt.

BRIEF DESCRIPTION.—The pea-nut belongs to the group of Papilionaceæ in the series of the Hedysariæ.

It is an herbaceous plant with stems creeping or erect, and it may attain a length varying with the species from 40 to 80 cm.

The leaves, composed of two pairs of oval leaflets, are alternate and generally have the lower surface covered with a light down, while their upper surface is smooth.

The fertile flowers are placed at the axils of the lower leaves when the stems are erect, but when the stems are creeping the flowers are disposed along their whole length. They are yellow in colour with red striations; the ovary is unilocular and contains a small number of ovules.

The flower is placed at the end of a long peduncle, which elongates immediately after fertilization and bends over towards the ground, pushing into it the ovary, which then begins to increase in size. The fruit is found at a depth of 5 or 6 cm., owing to its forcing its way down as it grows.

The fruit is an oblong or ovoid pod, of pale straw colour, and varies in size according to the variety. It contains from one to four seeds, covered by a papyraceous, coriaceous epidermis.

The seed is yellowish white, with cotyledons filled with oil, and covered by a reddish integument.

Cultivation.—The soils best suited to the growth of the pea-nut are light soils which allow the ovary to develop easily and so give a normal fructification.

It is impossible to give a specific composition for soils in which to grow pea-nuts, for there are a number of other factors to be considered in the growth of this plant. Light soils, well manured, or rich in humus, will be the best in view of the plant's particular fruiting and of its nature as one of the Leguminosæ.

At the same time, we may remark that soils rich in phosphoric acid and potash and containing a fairly high percentage of lime will suit this crop very well.

Growers should be warned of the need of applying manure with a lime base to soils deficient in lime. The greater the amount of assimilable nutritive matter the larger will be the crop of pea-nut.

In laterite soils the yields are good, provided the arable layer is sufficiently thick. In alluvial soils this plant thrives vigorously on account of the organic matter present, but it is possible that the quality of the crop may not be equal to that of crops grown in laterite soils, which are most widespread in volcanic and tropical countries. Briefly, although the pea-nut prefers a loam or silico-calcareous soil, containing enough organic matter to prevent excessive dryness, it will do well in any soil, provided it is not too dry, except compact clays and moist earths.

Although the pea-nut requires a certain amount of moisture, an excess of water is detrimental to growth; and if the plant is to escape attack by various cryptogams the soil should be able to drain easily.

The cultivation of the pea-nut may be considered from two points of view—as a main crop or as a catch crop.

In the first case expenses will be much higher, and whether the crop will be profitable or not will depend on local conditions of labour, land, transport, &c. In the second case, it is always worth while to have the land used either for the sake of the crop or for green manure, because

the labour is then paid for by a portion of the harvest, or ploughing in is compensated for by the cleaning which the land would otherwise have needed for the principal crop.

Another fact which must not be lost sight of is that the pea-nut is an improving crop, living at the expense of atmospheric nitrogen and accumulating an appreciable store of organic matter. When ploughed in as a green manure, the mineral principles are restored to the soil, and even the reaping of the crop cannot exhaust the soil, as all the dry leaves and stalks remain on the fields. The price obtained compensates for the materials withdrawn by the harvesting (materials which have only a relatively small value), and the greater part of the nitrogen may be returned to the soil by the stems and leaves left on the fields. This crop is then seriously worth consideration and should give very profitable results when grown in a mixed cultivation.

The climate most suited to the cultivation of the pea-nut is one whose mean shade temperature is from 25° to 27° C. Lower temperatures retard its development and higher ones are dangerous. In these countries it may be planted at any time of the year, but it thrives best in the main season and should therefore be planted at the vegetative check.

The most favourable conditions are a warm summer, with rainfalls at intervals, and relatively dry weather at harvest.

As we have already remarked, too damp a soil is unsuited to the pea-nut, and too frequent rains can only be detrimental. Sowing is begun immediately after the first rains. The soil must be sufficiently moistened to allow the seed to develop, and one of the marked advantages of this trailing plant is that it enables the soil to retain its moisture. Its branching stems cover the ground, and, except in cases of prolonged drought, by intercepting the sun's rays prevent the water from evaporating.

It is impossible to calculate a limiting value for rainfall; there are other factors to be taken into consideration in the growth of the plant.

Before sowing, the ground must be worked and cleaned

of weeds; in working on a large scale the plough must be used. Manuring is not absolutely essential, but spreading manure will always favourably affect the growth of Leguminosæ, and it is worth while spreading the field with a mixture of guano phosphates and ash. When the pea-nut is a subsidiary crop, the ground is already half prepared through the planting of the previous crop, and it only needs cleaning for sowing to be carried out. When the soil is well loosened small holes are made by hand, or, if it is too hard, with a spade, and a couple of stripped seeds are placed in each. In the interspaces of canes two parallel rows of holes are dibbled 50 to 60 cm. apart: one row in the middle of each interspace can also suffice, and with creeping varieties the ground will be sufficiently covered in this way.

It is always advisable to strip the seeds in order to be able to judge their quality better. Sowings from well-selected seeds of good quality always show a marked superiority over those selected carelessly. In West Africa the inferior quality of the sowings is said to be the cause of the degeneration observed in the seeds of certain districts.

Care must be taken that the young plants are not overrun by weeds until they are sufficiently sturdy to resist. Two months after sowing the ground should be hoed, not only to clean it, but to break up the surface soil in order that the ovaries may penetrate more easily. If hoeing is carried out during fruiting, care must be taken not to sever the peduncles which unite the pods to the stalk.

The stems are erect or creeping, according to the variety, and sowing should be carried out to correspond; that is to say, in one row with creeping varieties and in two with varieties having erect stems.

The distance to be allowed between plants will depend on the varieties, but if the ground is to be covered more quickly they may be planted closer. At the same time, this tendency must not be exaggerated or the plants will suffer.

Eight to ten days after sowing, two pale-green cotyledons

may be seen emerging from the soil, and subsequently several dark-green leaves are formed. Later on the branches develop, and thirty to forty days after sprouting flowering begins; it continues till growth is at an end.

Two and a half to three months after sowing the pea-nut is in full growth, and five months later the crop may be gathered. If sowing is in November, the month which in some countries marks the beginning of the vegetative check, harvest is in May. A double crop is feasible, but the second would probably be seriously endangered by excessive drought. Besides, it is never good to repeat the same crop; it is much more advisable to change about with other useful plants, such as the potato, for instance.

By the time the pea-nut has reached maturity, the plant has already begun to shrivel and a portion of the leaves has fallen; very frequently the stems are still green when the leaves are quite shrivelled. The seeds are not as yet mature. The stalks should be allowed to wither, the ripe pods can remain in the ground without harm. The only point is that, in this case, the cost of labour is increased, for the fruit needs digging up to be gathered; the best plan is not to wait until all the peduncles have become severed from the stalks, as when the plant is uprooted, with its stalk still green, the majority of the pods come away at the same time. It is true that a number of immature pods can be detected when this is done, but the resulting loss is balanced by the saving of labour.

Immature pods left in the ground will rot, while those which have reached maturity will keep, and will sprout the following year to form new plants.

The harvesting of a crop of pea-nut can be very expensive when grown on a large scale, and the result of the harvest may scarcely cover expenses; only natives, who do all the work themselves, with help from their wives and children, deriving any profit. But as a subsidiary or intercalary crop it is always worth growing.

Gathering is done either by hand or with implements

more or less peculiar to the different regions where the crop is grown. In operations on a large scale ricks are constructed which are protected from animals by a barrier of prickles, and from rain by a straw thatch. Women and children separate the pods from the stalks by hand when dry, or sometimes by threshing, but the first method is more usual. When labour is readily obtainable and the pea-nut grown as a secondary crop, as in Mauritius, the pods are detached, washed, dried on gunny, and finally placed in sacks. In that case the dead leaves are not used as fodder, but are left on the fields.

Varieties.—The varieties of pea-nut may be arranged in two classes: those with erect and those with trailing stems.

The varieties with trailing stems may be named *Arachis africana;* those with erect stems *A. asiatica.* The former bears fruits along the whole length of its stem, and the latter only on its lower portion, around the collar of the plant.

It would serve no purpose to enumerate all the variations in these two varieties, especially as the same varieties often have different names, according to the countries where they are grown. At the same time, we shall mention the American varieties with erect stems, the characteristics of which we have studied, and the Mauritian variety, which is said to be the best as regards yield, but which is not really indigenous there.

Yield.—The yield may vary within fairly wide limits, according to the variety and the general conditions of growth.

In Senegal, M. Adam says one cannot reckon on an average of more than 1,000 kilos per hectare, allowing for good and bad years. On the other hand, in certain parts of Senegal the yield may be from 3,000 to 4,500 kilos per hectare.

In Algeria the hectare brings in from 2,400 to 4,000 kilos of seeds (2,200 to 3,500 lb. per acre).

In the United States: Virginia, Tennessee, Georgia, and Carolina, the minimum yield, according to Semler, is 2,000 kilos per hectare (1,780 lb. per acre), but as much as 10,000 kilos per hectare (8,900 lb. per acre) has been realized.

In India, Bombay, the average yield for five years has been 5,600 kilos to the hectare.

In the United States, according to notes by Mr. Andrews, the use of manure has a great influence on the yield. At the experimental farm of Southern Pines, North Carolina, an allotment treated with 675 kilos of manure per hectare, containing 10 per cent. potash, 9 per cent. phosphoric acid, and 1 per cent. nitrogen, bore 2,000 kilos of pea-nut; whereas an unmanured allotment adjoining only yielded 460 kilos.

The following mixture has also given good results: 400 kilos superphosphate, 125 kilos potassium chloride, and 100 kilos of dried blood to the hectare.

In Barbados an average of 2,400 kilos is obtained, and occasionally as much as 4,800 kilos to the hectare.

In Mauritius, under ordinary conditions, one can reckon on a yield of 2,400 kilos to the hectare.

According to experiments carried out by M. Bonâme at the Agronomic Station, the yield in dry nuts is about 60 per cent. as, on the average, the seeds contain 40·5 per cent. of water, and the shells 55·2 per cent., the dry nuts containing 8 per cent. of water, and having a proportion of 75 per cent. seeds and 25 per cent. shells; 60 per cent. is the average figure obtained, the limits being from 55 to 70 per cent.

The yields have varied from 2,600 to 4,250 kilos to the hectare, according to the state of soil fertility, the weight of stems and leaves has also varied from 2,600 to 4,300 kilos.

The methods of cultivation also exert a marked influence, for instance, planting between rows of canes gave 1,300 to 1,350 kilos of pods, with a weight of stems and leaves from

1,900 to 2,400 kilos, and the following year from 710 to 1,200 kilos of nuts, whereas the ordinary method gave 1,800 kilos.

The following are the yields obtained at the stations at Réduit from sowings between rows of canes, only alternate rows being planted.

Yield in dry nuts:—

Spanish nuts in	two rows	... ...	881 kilos
,, ,,	one row	... ...	782 ,,
Tennessee ,,	two rows	... ...	1,080 ,,
Bunch ,,	two rows	... ...	1,139 ,,
,, ,,	one row	... ...	770 ,,
Virginian ,,	one row	... ...	794 to 948 ,,
Ordinary ,,	one row	... ...	746 ,, 817 ,,
Madagascan,,	two rows	... ...	834 ,, 995 ,,

On a large sugar plantation, where the pea-nut was grown as an inter-crop, the yield in green nuts was, on an average, from 1,650 to 1,900 kilos to the hectare, and the maximum reached 3,080 to 3,320 kilos.

Composition.—The number of seeds to a hundred pods varies but little, even in different countries:—

	Senegal	India	La Plata	Mauritius
Shells, per cent...	25·00	21·50	26·00	26·00
Seeds, ,, ...	75·00	78·50	74·00	74·00

The average generally adopted in trade is 75 per cent. These proportions vary a little in the different varieties, and we append a table showing the result of observations at the Agronomic Station of the Island of Mauritius.

Weight in grm. of 100 full pods	Bunch	Tennessee	Virginian	Spanish	Ordinary	Madagascan
Seeds	164	218	167	97	92	85
Shells	61	64	63	39	32	22
Pods (full) ...	225	282	230	136	124	107
Percentage weight of seeds	72·00	77·00	73·00	71·00	74·00	79·00
Number of seeds in 100 pods	196	308	196	200	200	110
Weight of a seed in grm.	0·830	0·704	0·852	0·485	0·460	0·772

The amount of oil present in the seeds varies not only according to the varieties, but with the climate as well. This variation is difficult to explain, and we must be content merely to state that the proportion of fatty matter is higher or lower, according to the more or less favourable conditions of growth and distribution of rainfall. It has been remarked that, even in the same district and with a similar variety, the fatty matter varies from year to year.

We give below the average composition of the pea-nuts of various countries.

ORDINARY COMMERCIAL PEA-NUTS—MATTER DEVOID OF MOISTURE.

In 100 seeds	United States	Spain	Bombay	Japan	Egypt	Congo	Mauritius
Ash	2·40	2·72	3·32	1·93	2·35	2·73	2·56
Cellulose	2·37	3·50	2·33	4·88	1·61	1·55	5·33
Fat	49·35	41·17	50·47	54·54	52·30	52·88	51·14
Non-nitrogenous matter	17·23	20·43	10·15	15·99	20·27	14·51	12·40
Nitrogenous matter	28·65	32·18	33·73	22·66	22·97	28·33	28·57
	100·00	100·00	100·00	100·00	100·00	100·00	100·00

[1] The figures in the first six columns are taken from "L'Arachide" of J. Adam.

It will be noticed that the oil content is everywhere about the same, except in Japan.

In reducing these figures to terms of the whole pod the gross proportion of oil may be ascertained:—

Senegal	44·7 per cent.
United States	38·6 ,,
Egypt	41·7 ,,
Congo	40·3 ,,
Bombay	43·0 ,,
Spain	43·2 ,,
Mauritius	40·0 ,,

Among the varieties tested at the Agronomic Station there is also no appreciable difference between the various proportions of fatty matters. The following analyses were published in the annual report for 1910:—

Stripped seeds	Ordinary	Virginian	Spanish	Bunch	Tennessee	Average
Water...	7·32	8·54	6·70	8·30	6·56	7·48
Ash ...	2·30	2·66	2·18	2·60	2·34	2·38
Cellulose	3·45	2·82	4·50	3·24	3·74	3·55
Fat ...	43·70	42·34	45·90	42·56	44·22	43·75
Sugars	5·34	5·50	5·00	4·30	3·76	4·78
Non-nitrogenous matter	9·73	9·70	10·29	10·61	7·33	9·53
Nitrogenous matter	28·16	28·44	25·43	28·39	32·05	28·53
	100·00	100·00	100·00	100·00	100·00	100·00
Nitrogen	4·49	4·55	4·07	4·53	5·13	4·55

Shells	Ordinary	Virginian	Spanish	Bunch	Tennessee	Average
Water	12·84	12·94	12·30	13·16	11·16	12·48
Ash ...	1·98	2·44	2·18	1·68	2·44	2·14
Nitrogen	0·56	0·50	0·61	0·43	0·72	0.56

The only specific difference between these varieties is the size of their pods, and this is confirmed by a study of the respective weights we have given.

What fertilizing matters are withdrawn from the soil by a crop of pea-nuts?

The researches made in order to clear up this point are of considerable interest, and the following figures are taken from Bulletins 21 and 25 of the Agricultural Station at Mauritius:—

Ordinary Commercial Pea-nuts.

	Percentage composition of ash		Mineral matter in 100 parts of natural substance	
	Seeds	Shells	Seeds	Shells
Silica ...	0·73	18·08	0·018	0·434
Chlorine	1·41	0·85	0·034	0·020
Sulphuric acid ...	3·78	1·74	0·091	0·042
Phosphoric acid	33·96	2·64	0·815	0·063
Lime ...	3·83	11·45	0·092	0·275
Magnesia	15·21	5·31	0·365	0·127
Potash	35·61	4·58	0·854	0·110
Soda ...	2·05	1·44	0·049	0·035
Oxides of iron and alumina	0·90	47·07	0·022	1·130
Carbonic acid, &c.	2·52	6·84	0·060	0·164
	100·00	100·00	2·400	2·400
Nitrogen	—	—	4·259	0·610

1,000 kilos of whole nuts gives the following distribution of these elements in the seeds and shells:—

	In the seeds Kilos	In the shells Kilos	Whole nuts Kilos
Silica	0·138 ...	1·003 ...	1·141
Chlorine	0·261 ...	0·046 ...	0·307
Sulphuric acid	0·700 ...	0·097 ...	0·797
Phosphoric acid ...	6·267 ...	0·146 ...	6·413
Lime	0·708 ...	0·635 ...	1·343
Magnesia	2·807 ...	0·293 ...	3·100
Potash	6·567 ...	0·254 ...	6·821
Soda	0·377 ...	0·081 ...	0·458
Oxides of iron and alumina	0·169 ...	2·610 ...	2·779
Carbonic acid, &c. ...	0·462 ...	0·379 ...	0·841
Total mineral matter ..	18·456 ...	5·544 ...	24·000
Nitrogen	33·560 ...	1·409 ...	34·969
Dry matter	718·630 ...	208·360 ...	926·990
Natural matter ...	769·000 ..	231·000 ...	1,000·000

The high proportion of iron oxide in the husks is due merely to the earth, from which it is impossible to free the pods completely.

The nuts harvested at the Agronomic Station gave the following results, the proportion of seeds being about 78 per cent. of the amount of whole fruit:—

	Percentage composition		In 100 pods gross		
	Seeds	Shells	In seeds	In shells	Whole pods
Water	5·14 ...	9·10 ...	4·03 ...	1·96 ...	5·99
Ash	2·88 ...	2·06 ...	2·26 ...	0·44 ...	2·70
Cellulose	2·63 ...	65·45 ...	2·06 ...	13·87 ...	15·93
Fat	43·28 ...	1·00 ...	33·97 ..	0·22 ...	34·19
Sugars	3·00 ...	— ...	2·36 ...	— ...	2·36
Non-nitrogenous matter	14·14 ...	17·71 ...	11·11 ...	4·01 ...	15·12
Nitrogenous matter ...	28·93 ...	4·68 ...	22·71 ...	1·00 ..	23·71
	100·00 ...	100·00 ...	78·50 ...	21·50 ...	100·00

	Percentage composition of ash		Mineral matter in 100 parts natural substance	
	Seeds	Shells	Seeds	Shells
Silica	0·68 ...	12·90 ...	0·017 ...	0·406
Chlorine	0·38 ...	0·91 ...	0·009 ...	0·029
Sulphuric acid	2·92 ...	2·39 ...	0·075 ...	0·075
Phosphoric acid	42·90 ...	5·50 ...	1·071 ...	0·173
Lime	3·61 ...	25·32 ...	0·090 ...	0·798
Magnesia	14·07 ...	4·18 ...	0·352 ...	0·132
Potash	33·52 ...	7·29 ...	0·833 ...	0·230
Soda	0·68 ...	0·54 ...	0·017 ...	0·017
Oxides of iron and alumina	0·27 ...	24·73 ...	0·007 ...	0·779
Carbonic acid, &c. ...	0·97 ...	16·24 ...	0·029 ...	0·511
Total mineral matter ...	100·00 ...	100·00 ...	2·500 ...	3·150
Nitrogen	— ...	— ...	4·700 ...	0·900

It is interesting to note that the proportions of various nutritive elements in the ordinary commercial pea-nut grown in various localities, and in those grown at Réduit, are practically identical. In relating the figures cited to 1,000 kilos of fruit, the difference is only appreciable for phosphoric acid and lime; the potash, magnesia and sulphuric acid remaining the same.

	In the seeds Kilos	In the shells Kilos	Whole fruits Kilos
Silica ...	0·130	0·930	1·060
Chlorine	0·070	0·170	0·170
Sulphuric acid ...	0·580	0·170	0·750
Phosphoric acid	8·250	0·400	8·650
Lime ...	0·690	1·840	2·530
Magnesia	2·710	0·300	3·010
Potash	6·450	0·530	6·980
Soda ...	0·130	0·040	0·170
Oxides of iron and alumina	0·050	1·790	1·840
Carbonic acid, &c.	0·190	1·170	1·360
Total mineral matter	19·250	7·240	26·490
Nitrogen	36·200	2·070	38·270
Dry matter	744·700	195·400	940·100
Natural matter...	785·000	265·000	1,000·000

The pea-nut is cultivated either for the crop of fruit, or for ploughing in as green manure. In the first case, we have already seen what fertilizing substances may be withdrawn from the soil by the harvest, and it is easy to ascertain if the loss of these substances is balanced by the price the crop fetches. The nitrogen may be neglected through the very nature of the plant as one of the Leguminosæ, enriching the soil as it does in nitrogen, obtained from the atmosphere, in spite of the amount withdrawn by the harvest.

When sown between rows of canes, the weight of the stems, while still green, may vary from 1,900 to 2,400 kilos. When the stems have reached maturity from 24 to 28 tons (metric) of green manure may be obtained from a full crop.

In several experiments at Réduit, a crop sown between rows of canes (one row in two) gave, at the end of three

months, the following yield of stems and leaves to the hectare :—

Spanish pea-nut	...	...	...	...	5.940 kilos.
Bunch ,,	...	...	...	...	13,150 ,,
Virginian ,,	...	...	...	...	10,050 ,,
Ordinary ,,	...	...	...	...	12,625 ,,
Madagascan ,,	...	...	...	...	10.425 ,,

These stems and leaves showed the following composition :—

	Spanish	Bunch	Virginian	Ordinary	Madagascan
Water	75·80	80·20	78·30	84·90	78·70
Ash	1·73	1·48	1·61	1·45	1·64
Cellulose	6·76	5·17	7·23	4·87	6·06
Fat	2·13	1·26	1·37	0·33	0·98
Sugars...	—	—	1·04	—	1·70
Non-nitrogenous matter ...	10·54	8·82	7·06	6·38	8·59
Nitrogenous matter ...	2·94	3·07	3·30	2·07	2·33
	100·00	100·00	100·00	100·00	100·00
Nitrogen	0·47	0·49	0·54	0·33	0·37

COMPOSITION OF THE DRY MATTER.

	Spanish	Bunch	Virginian	Ordinary	Madagascan
Ash	7·15	7·50	7·40	9·60	7·70
Cellulose	27·03	26·10	33·30	32·25	28·44
Fat	8·80	6·38	6·32	2·21	4·60
Sugars	—	traces	4·80	-	8·00
Non-nitrogenous matter ...	43·94	44·52	32·56	42·26	40·26
Nitrogenous matter ...	12·18	15·50	15·62	13·68	11·00
	100·00	100·00	100·00	100·00	100·00
Nitrogen	1·95	2·48	2·50	2·19	1·76

From the yields quoted it may be seen that the spacing of the plantation should vary according to the particular variety sown. It should be noticed, however, that the Bunch variety, with erect stems, yielded a larger amount of green matter than the ordinary variety, with its trailing stems, which shows that, according to the method of cultivation, these two varieties may give equally good results.

Appended is the content of these plants in fertilizing

[Photo by G. Rehaut.

matters which are returned to the soil when the stems and leaves are ploughed in.

PERCENTAGE COMPOSITION OF ASH.

	Spanish	Bunch	Virginian	Ordinary	Madagascan
Silica ...	10·34	5·60	7·67	5·04	8·28
Chlorine	2·48	2·34	2·94	3·12	2·62
Sulphuric acid	4·45	3·77	3·04	3·02	4·66
Phosphoric acid	6·53	5·67	5·48	4·27	5·28
Lime ...	16·84	17·92	17·47	14·22	23·38
Magnesia	11·64	7·72	14·68	8·10	10·50
Potash...	17·25	25·08	21·72	30·64	19·12
Soda ...	0·43	2·00	2·02	1·48	1·30
Oxide of iron	13·20	8·43	11·94	7·20	7·96
Carbonic acid, &c.	16·84	21·47	13·04	22·91	16·30
	100·00	100·00	100·00	100·00	100·00

MINERAL CONTENT OF 100 KILOS OF GREEN MATTER.

	Spanish Kilos	Bunch Kilos	Virginian Kilos	Ordinary Kilos	Madagascan Kilos
Silica ...	0·179	0·083	0·123	0·073	0·135
Chlorine	0·043	0·035	0·047	0·045	0·043
Sulphuric acid	0·077	0·056	0·049	0·044	0·076
Phosphoric acid	0·113	0·084	0·088	0·062	0·091
Lime ...	0·292	0·264	0·281	0·206	0·393
Magnesia	0·201	0·114	0·237	0·118	0·172
Potash...	0·298	0·370	0·350	0·444	0·313
Soda ...	0·007	0·030	0·033	0·022	0·021
Iron oxide	0·228	0·125	0·192	0·104	0·130
Carbonic acid, &c.	0·292	0·319	0·210	0·332	0·266
	1·730	1·480	1·610	1·450	1·640

MINERAL CONTENT OF 100 KILOS OF DRY MATTER.

	Spanish Kilos	Bunch Kilos	Virginian Kilos	Ordinary Kilos	Madagascan Kilos
Silica ...	0·739	0·420	0·568	0·484	0·638
Chlorine	0·177	0·176	0·218	0·300	0·202
Sulphuric acid	0·318	0·283	0·225	0·290	0·359
Phosphoric acid	0·467	0·425	0·406	0·410	0·407
Lime ...	1·204	1·344	1·293	1·365	1·846
Magnesia	0·832	0·579	1·086	0·778	0·809
Potash...	1·234	1·880	1·607	2·941	1·472
Soda ...	0·031	0·150	0·149	0·142	0·100
Oxide of iron	0·044	0·632	0·883	0·691	0·613
Carbonic acid, &c.	1.204	1·611	0·965	2.199	1·254
	7·150	7·500	7·400	9·600	7·700

COMPOSITION OF TOTAL HARVEST FROM 1 ARPENT (= 0·413 HECTARE).

	Spanish Kilos	Bunch Kilos	Virginian Kilos	Ordinary Kilos	Madagascan Kilos
Silica	4·564	4·607	5·215	3·891	5·940
Chlorine	1·096	1·943	1·993	2·398	1·892
Sulphuric acid	1·963	3·108	2·078	2·345	3·344
Phosphoric acid	2·881	4·662	3·731	3·305	4·004
Lime	7·446	14·652	11·914	10·980	17·292
Magnesia	5·126	6·237	10·049	6·289	7·568
Potash	7·600	20·535	14·840	23·665	13·772
Soda	0·178	1·665	1·399	1·167	0·924
Iron oxide	5·814	6·938	8·141	5·543	5·720
Carbonic acid, &c.	7·446	17·793	8·904	17·700	11·704
Total mineral matter	44·114	82·140	68·264	77·283	72·160
Weight of green crop	2,550·000	5,550·000	4,240·000	5,330·000	4,400·000
,, dry ,,	607·1	543·9	920·000	804·8	937·2
Nitrogen content	11·98	27·19	22·89	17·59	16·28

:: When the plants were not mixed with any other crop, the stems were less shrivelled and still carried the majority of the leaves; the weight harvested was 9,000 kilos.

When the pods are gathered the stems are already half shrivelled and the leaves fallen; after a mixed cultivation (every second row) a weight was obtained of 2,100 kilos of stems to the hectare.

	Percentage composition I	Percentage composition II	In 100 parts of dry matter I	In 100 parts of dry matter II
Water	69·40	75·50	—	—
Ash	4·28	2·27	14·00	9·28
Cellulose	14·37	9·82	46·97	40·10
Fat	0·41	0·42	1·35	1·73
Sugars	—	1·22	—	5·00
Non-nitrogenous matter	9·13	8·33	29·80	33·64
Nitrogenous matter	2·41	2·44	7·88	10·25
	100·00	100·00	100·00	100·00
Nitrogen	0·385	0·39	1·26	1·64

	In 100 parts of ash I	In 100 parts of ash II	In 100 parts of stems I	In 100 parts of stems II	In 100 parts of dry matter I	In 100 parts of dry matter II
Silica	14·90	5·20	0·638	0·118	2·086	0·483
Chlorine	3·51	3·26	0·150	0·074	0·491	0·303
Sulphuric acid	3·67	3·70	0·157	0·084	0·514	0·343
Phosphoric acid	1·31	4·10	0·056	0·093	0·183	0·381
Lime	13·02	14·89	0·557	0·338	1·823	1·382
Magnesia	7·03	6·91	0·301	0·157	0·984	0·641
Potash	27·83	33·15	1·191	0·752	3·896	3·076
Soda	1·90	1·48	0·081	0·034	0·266	0·137
Oxides of iron and alumina	12·97	6·99	0·556	0·159	1·816	0·649
Carbonic acid, &c.	13·86	20·32	0·593	0·461	1·941	1·885
Total mineral matter	100·00	100·00	4·280	2·270	14·000	9·280
Nitrogen	—	—	0·385	0·390	1·260	1·640

We see that in Spain and in Egypt the stems of pea-nuts cut when the fruit has reached maturity only contain 31 and 32 per cent. of water, whilst the proportion of nitrogen is 1·87 and 1·58 per cent.

According to comparisons which we have been able to make between the figures obtained in Mauritius and those from other countries, such as West Africa, India, and America, the essential difference between various species of pea-nut seems to be not so much in the proximate composition as in the mineral composition.

The differences which exist, arise, in all probability, just as much from the varieties planted as from the conditions of growth and of climate. The figures quoted are sufficient to give an exact idea of the composition of this plant and to guide those who wish to grow it.

As the fruit appears concurrently with the florescence, *immature pods may be encountered, even when the plant* is pulled green.

In a planting at Réduit, Mauritius, made on December 12th, between rows of canes, and pulled seventy-five days later, that is to say, when in full growth, the weight harvested was 9,950 kilos to the hectare, of which the stems and leaves accounted for 84 per cent. and the seeds for 16 per cent., thus:—

Stems and leaves	8,350 kilos
Seeds	1,600 „
	9,950 „

The seeds contained on an average only 8·48 per cent. of fat, and 0·92 of nitrogen. The proportion of phosphoric acid reached only 20 per cent., instead of 35 and 40 per cent.

In the 9,950 kilos harvested the amount of phosphoric acid found, in round figures, amounted to only 9 kilos, that of potash 58·3, and that of nitrogen 44·1.

Thus, when the crop is used as green manure, the demands made are greater; nevertheless, as we have remarked already, the yield will be all the greater if the soil

is in good tilth, well provided with soluble assimilable elements, and sufficiently rich in organic matter. In fact, these conditions are essential for either a good green or a good fruit crop.

USES.—The cultivation of the pea-nut yields several products which are useful both as food for man and fodder for beasts.

These products are as follows: Seed, oil, oil cake, and fodder.

The utilization of the seed dates back to the century in which it was first discovered, and it is curious to note that all the uses to which the pea-nut is turned to-day were already known then.

The *Bulletin de Paris*, dated 5th Floreal, year X, No. 10, states that in Spain oil of splendid quality is obtained from this plant and that it is also used in the manufacture of chocolate; further, when combined in equal parts with the flour of wheat, the flour obtained from the residue is used in the manufacture of bread. "The fruit, when roasted," adds the *Bulletin de Paris*, "has a fairly pleasant flavour, and there is no reason why it should not be used in the manufacture of chocolate, as in Spain."

Cossigny relates that citizen Alexandre, of Mont de Marsan, who was a clever chemist, manufactured from pea-nuts "an almond paste, a cream for the complexion and skin chaps, &c., soap, almond syrup, soap extract, hair oil, and finally, by means of the roasted seed, a liqueur."

The seed may be eaten either raw or roasted. It enters into the composition of numerous dishes in those countries where it is indigenous; in Europe it is chiefly used in confectionery and in the manufacture of chocolate.

An account of its composition has already been given. The various commercial methods of extracting oil from the seed vary in different localities. In countries where it is indigenous the method is primitive, while in the European centres use is made of powerful machinery.

Oil is obtained from three successive applications of pressure. First the pods are cleaned and shelled, the seeds are then stripped, and finally dressed and air dried.

This series of treatments separates the seeds from shell and episperm.

From the first application of pressure, without heat, is obtained the superfine oil, which ranks as equal to olive oil, and is eaten as such so long as it remains fresh. The two remaining applications of pressure yield oils of second and third quality, which are used for soap-making and lubricating purposes. The yield varies with the variety and with the methods of extraction.

In Senegal the yield from stripped seeds was as follows:—

Oil	30·55 per cent.	first application of pressure
"	8·33 "	second "
"	6·94 "	third "
	45·82	

Appended is a table compiled by M. Baron, consulting chemist at Marseilles (taken from M. Lecomte's treatise on the Egyptian pea-nut), which gives the yield for commercial purposes from pea-nuts of different regions:—

Rufisque (Senegal)	31 to 31·5 per cent.
Gambia	30 " 31 "
Mozambique	42 " 45 "
Bombay	37 " 38 "
Coromandel	36 " 37 "
Egypt	31·5 "

The oil of the pea-nut has an average density of 0·918 at 15° C.

Appended is an analysis made for a factory in Mauritius.

Density at 15° C.	0·918
Maumené test. Thermal reaction with H_2SO_4 ...	44° C.
Fatty acids	96·2 per cent.
Acidity expressed in SO_3	0·11
Arachic acid	4·35
Iodine number (Hubl)	102·5
Saponification value (Koettstorfer)	193
Melting point of fatty acids	33·5° C.

The residue of the third expression forms the oil cake, which thus varies in composition according to whether the nuts were decorticated or not when pressed. The former are called in trade pea-nut cakes, and the latter coarse or strawy cakes.

If the pressure is carried out without the application of heat the oil content is higher, and the manufacturer suffers a loss.

	Cold expression	Expression with heat
Water	14·40	15·20
Ash...	6·26	7·94
Cellulose	4·34	8·05
Fat	17·80	8·08
Non-nitrogenous matter ...	19·20	20·42
Nitrogenous matter	38·00	40·31
	100·00	100·00

According to M. Grandeau, the composition of cake made from decorticated pea-nuts, compared with linseed and rape cakes, frequently used as fodder, is as follows:—

	Decorticated pea-nut	Undecorticated pea-nut	Linseed	Rape
Water	11·5	9·8	11·8	10·4
Ash	4·9	6·9	7·3	7·7
Cellulose	5·2	22·7	9·4	11·3
Fat	7·3	8·9	10·7	9·8
Non-nitrogenous matter ...	24·1	20·7	32·1	30·1
Nitrogenous matter .	47·0	31·0	28·7	30·7

Pea-nut cakes, whether prepared by the hot or by the cold method, and whether from decorticated or undecorticated seeds, have an important nutritive value for dairy cattle.

The nitrogen content is 6 to 7 per cent. and their commercial value either as animal fodder or as manure reduces the cost price of the oil and renders the cultivation of the pea-nut more remunerative.

The best plan is to use them as cattle fodder, particularly for milch-cows, as the fertilizing elements are then preserved in the farmyard manure.

Their mineral composition is as follows:-

	In 100 parts of ash	In 100 parts of cake
Silica	23·34 ...	1·844
Chlorine	0·42 ...	0·033
Sulphuric acid	2·31 ...	0·183
Phosphoric acid...	18·27 ...	1·443
Lime	4·25 ...	0·336
Magnesia	7·25 ...	0·573
Potash...	20·38 ...	1·610
Soda	2·84 ...	0·224
Oxides of iron and alumina ...	19·60 ...	1·548
Carbonic acid, &c.	1·34 ...	0·106
	100·00	7·900
Nitrogen	—	6·43

When the cakes are manufactured from decorticated seed, though the husks have not a high value as fodder, they may still be useful when soaked in molasses. Further, the value of the shells leaving the decorticator is increased through the remains of seed mixed with them.

The composition of the stems and leaves as fodder has already been noted. In certain countries where fodder is scarce even the dry stems are used as hay. Its use just depends on what relish animals show for it.

Finally, in concluding this account, we can only urge every sugar-cane grower to make use of the spaces between his canes to cultivate the pea-nut; it will not only furnish him with a remarkable green manure, but will enrich his soil, lessen the cost of upkeep of his main crop, and thus be a source of real profit.

Production.—The chief centres for the cultivation of the pea-nut are: Senegal, Java, Egypt, French India, British India, Argentine, Sierra Leone, &c.

The following figures showing the amount and value imported by Europe will serve to give some idea of the production:—

	1904		1905	
	Weight in metric tons	Value in francs	Weight in metric tons	Value in francs
France	93,338 ...	14,356,339 ...	69,530 ...	10,682,031
England and colonies ...	1,052 ...	160,070 ...	431 ...	56,095
Germany	8,161 ...	1,289,188 ...	4,619 ...	738,311
Belgium	4,517 ...	722,659 ...	2,677 ...	408,587
Holland	24,327 ...	3,814,707 ...	18,067 ...	2,834,040
Other countries	6,389 ...	927,226 ...	851 ...	132,160
Total to countries other than France	44,446 ...	6,963,850 ...	26,645 ...	4,169,193
Grand total	137,784 ...	21,320,189 ...	96,175 ...	14,851,224

According to a passage from the *Rapport général de l'Exposition de Marseille,* 1907, by M. E. Charabot, the export of pea-nuts has fallen off during the last few years.

VOANDZEIA SUBTERRANEA (BAMBARRA GROUND-NUT).

This nut, a native of Madagascar, is called the Bambarra ground-nut, or Voandzou, its scientific name being *Voandzeia subterranea.*

Although the plant shows considerable similarity with the ordinary pea-nut, it has a completely different composition and does not serve the same purposes. Like the pea-nut, the Bambarra ground-nut is a leguminous plant and may be grown as a subsidiary crop. Its vegetation is similar and shows the same rosette of erect leaves; the fruit develops around the stem just beneath the surface of the soil, and by remaining attached to the plant facilitates the work of picking. Any fruit which remains behind can be speedily gathered.

Its requirements in the matter of cultivation are the same as those of the pea-nut, and it may, in the same way, be grown between rows of canes. It may be planted in two parallel lines, either in successive or in alternate inter-rows. The crop is harvested directly the leaves and stems begin to shrivel.

The yield may equal that of the ordinary pea-nut; for instance, in one of the trials we made we obtained from a seeding between rows of canes (every other row), 2,315 kilos of green nuts and 2,735 kilos of green leaves per hectare.

Green nuts usually only yield 40 per cent. of dry nuts. The fruit is eaten when green, owing to the fact that when dry it appears to be difficult to cook, and must be crushed before use.

	Green nuts		Ripe nuts	
	Natural substance	Dry matter	Natural substance	Dry matter
Water	58·50	—	12·52	—
Ash	1·65	3·97	3·94	4·50
Cellulose	3·03	7·31	5·65	6·45
Fat	3·10	7·46	6·14	7·02
Non-nitrogenous matter	26·41	63·64	57·07	65·26
Nitrogenous matter ...	7·31	17·62	14·68	16·77
	100·00	100·00	100·00	100·00

[*Photo by G. Réhaut.*

FIG. 4.—*Voandzeia subterranea* (Madagascan Ground-nut).

The husks only contain 1·55 per cent. nitrogenous matter in the green fruit and 7·31 per cent. in the ripe fruit.

The dry leaves and stems might be used for fodder, but as no trial has yet been made, the question arises whether beasts would have any liking for this somewhat coarse sort of nourishment, which contains as much as 45 to 50 per cent. cellulose.

As there has been occasion to remark, the seeds possess a considerable nutritive value, and when crushed up dry with the husks might be used as fodder for stock.

	Whole ripe fruit
Water	12·50 per cent.
Ash	4·21 ,,
Cellulose	9·60 ,,
Fat	6·41 ,,
Non-nitrogenous matter	53·17 ,,
Nitrogenous matter	14·11 ,,
	100·00 per cent.

In establishing the nutritive ratio it is seen that this leguminous plant is a complete food, for if we take one part of fatty matter as equivalent to two parts of matter containing carbohydrates, the relation of nitrogenous matter to non-nitrogenous matter is as 4 : 7. This proportion constitutes a normal food, and this without taking any account of the cellulose.

The ordinary pea-nut does not seem to make as great a call on the fertilizing elements as the *Voandzeia*, the requirements of which are apparently greater.

	In 1,000 kilos of fruit	
	Ordinary pea-nuts	Madagascan nuts
Nitrogen	38·27 ...	21·4
Lime	2·53 ...	1·148
Phosphoric acid	8·65 ...	5·656
Potash	6·98 ...	17·735
Magnesia	3·01 ...	2·656

The nitrogen, being derived from the atmosphere, may be neglected, and although the amount of phosphoric acid is 3 kilos higher in the ordinary pea-nut, on the other hand there is treble the amount of potash in the *Voandzeia*.

In any case, it is a most useful plant, yielding a healthy provender at a low price. As a leguminous, that is to say, as a restorative plant, we prefer its rival, which, by its greater spread of leaf surface, will yield a larger amount of manure of higher nitrogen content.

CANAVALIA ENSIFORMIS (JACK BEAN).

The Jack Bean found in our gardens is a native of India, and derives its name, *Canavalia ensiformis*, from the Tamil name *canavali*.

Practically all the Canavalia are natives of India, and the species under our present notice was discovered in the East Indies in 1778. The date of its introduction to Mauritius can hardly be determined, but all the evidence points to its having been the work of the numerous Indian emigrants.

Bojer, in his "Hortus Mauritianus," speaks of *Canavalia obtusifolia* as being a native of Mauritius and the other islands of Africa.

C. gladiata has pinkish seeds, those of the Nossi-Bé variety being red. Both these are trailing varieties and produce but little fruit, though preference should be given to the species *C. gladiata*, whose wealth of foliage is magnificent. In 1837, when Bojer wrote his book, four varieties of Canavalia were known in Mauritius (*C. obtusifolia, C. emarginata, C. gladiata, C. ensiformis*).

No importance seems to have been attached to these plants until quite recently, when the Director of the Agricultural Station undertook experiments to show the great value of this plant, not only as a restorative crop, but also as a table vegetable. His views have now become widely known and this plant is in remarkable favour; the amount under cultivation is increasing every year, and the false notions concerning it are in a fair way to disappear.

M. Bonâme has published an elaborate treatise on the Jack Bean in his annual report for 1909. In my position as collaborator with the Director of the Station, I have been able to follow these experiments closely and to carry out a number of analyses. As, in our joint survey of the whole of the literature of the Leguminosæ, we have found nothing whatever on this species, we think it advisable to give an

account *in extenso* of all that has been done and published on it by the Agricultural Station of Mauritius.

The Jack Bean is a shrub which thrives well in every portion of the Island, and its pod while green and immature forms an excellent table vegetable.

These pods are, perhaps, superior to those of the haricot bean and all those who have partaken of them judge their flavour excellent. Just before the seeds are quite ripe, but well formed, they may be shelled and cooked in the same way as kidney beans and are then equally good.

The Jack Bean is of rich growth; it easily attains a height of 2 ft. (64 cm.); the stems are slightly branched and possess large leaves which cover the ground well, but the plant is not a climber and will not overrun others. It may easily be grown between canes, and when in full growth can be ploughed in as green manure. The insect which occasionally destroys young beans and cowpeas does not attack this, and it may be sown throughout the year, though the most favourable season in Mauritius is from November to February and March. At certain periods of the year, however, the pods are attacked by grubs, which destroy a large number of seeds. This nuisance is chiefly evident in a small crop; no doubt over a large area the damage done would be relatively less important. This is a fact which can often be noticed; experimental crops are often attacked in such a way that it might almost be believed that the whole tribe of insect pests had agreed to meet in that particular spot, whereas the damage in a large crop passes unnoticed.

It is a good thing to introduce any new plants which may benefit agriculture, but that is no reason why indigenous plants which are already acclimatized and which are capable of giving equally good results should be neglected.

The Jack Bean is an easy plant to grow. When planted from December to January it is in full growth and flower three months later; if grown for green manure it should

then be ploughed in; if left later the pods ripen and a portion of its leaves fall. As soon as the plant has begun to flower, its pods, which are soon formed, make an excellent vegetable at a period of the year when vegetables are

[Photo by G. Keland.

FIG. 5.—*Canavalia ensiformis* (Jack Bean).

rather scarce. Its yield is a large one, and when planted between canes, every second row, should give at least 4,700 lb. of green pods of splendid quality per hectare. The

plants in the rows should be placed at greater or smaller intervals, according as to whether the pods are to be gathered with the seeds or the crop is to be ploughed in. All the pods, even when only one-quarter developed, are of large size; the best cooking bean being from 15 to 20 cm. long and weighing from 15 to 30 grm.

The following table gives their composition as compared with that of ordinary haricot beans given by M. Balland:—

	In 100 parts of natural substance			In 100 parts of dry matter		
	Jack beans I	Jack beans II	Haricot beans	Jack beans I	Jack beans II	Haricot beans
Water ...	87·80	88·56	90·0 to 94·0	—	—	—
Ash ...	0·54	0·75	0·70 ,, 0·8	4·42	6·56	9·7 to 11
Cellulose ...	1·77	1·67	0·40 ,, 0·9	14·53	14·60	7·0 ,, 13
Fat ...	0·22	0·38	0·15 ,, 0·3	1·79	3·32	1·9 ,, 3·4
Non-nitrogenous matter ...	7·86	5·83	3·0 ,, 4·2	64·39	50·96	50·0 ,, 52·0
Nitrogenous matter ...	1·81	2·81	1·7 ,, 2·0	14·87	24·56	25·0 ,, 28·5
	100·00	100·00		100·00	100·00	
Nitrogen ...	0·29	0·45		2·38	3·96	

When the pods have been allowed to develop till the seeds are formed, but before they have reached maturity, the latter may be eaten without the shell; they then cook splendidly, whereas when allowed to ripen they can only be softened with difficulty.

Raoul says the wild Indian variety is supposed to be poisonous, and advises using the seed when half ripe and still soft; he thinks this question should be gone into. For ourselves, we and a number of other people have often eaten it without any subsequent discomfort, and we happen to know that at Réduit and elsewhere the crop has often been pillaged by "amateurs" who certainly did not share the prevailing opinion.

When the seeds are half ripe, the shells, of course, can no longer be eaten; but they might be made use of for animals, such as pigs and others. Once the seed is formed the green pods have reached the height of their develop-

ment; each pod weighs from 100 to 125 grm., and contains ten to twelve seeds.

One hundred grammes of whole pods give 83 grm. of husks and 17 grm. of seed: one seed weighs about 1½ grm.

In this state the composition of the pod is as follows:—

	Percentage composition		Composition of the full pod		
	Seeds	Husks	In the seeds	In the husks	Full pod
Water	75·50	81·00	12·83	67·23	80·06
Ash	0·93	0·88	0·16	0·73	0·89
Cellulose	3·73	4·95	0·63	4·12	4·75
Fat	0·61	0·38	0·10	0·32	0·42
Sugars	1·38	2·54	0·23	2·11	2·34
Non-nitrogenous matter	9·47	8·17	1·63	6·77	8·40
Nitrogenous matter ...	8·38	2·08	1·42	1·72	3·14
	100·00	100·00	17·00	83·00	100·00
Nitrogen	1·34	0·334	0·227	0·277	0·504

When the crop is allowed to remain the pods ripen completely; the seeds remain about the same weight, but naturally contain less water and a greater amount of nutritive matter; each empty pod then weighs from 25 to 30 grm., and the average weight of a seed is 1·4 grm.

Five different samples yielded 57 and 58 per cent. of seeds, and 43 and 42 per cent. of shell respectively.

PERCENTAGE COMPOSITION OF RIPE PODS.

	I		II		Average	
	Seeds	Husks	Seeds	Husks	Seeds	Husks
Water	13·03	15·20	15·36	11·46	14·18	13·33
Ash ...	3·22	5·78	3·60	6·84	3·41	6·31
Cellulose	7·90	57·91	9·97	39·60	8·93	48·75
Fat ...	2·32	0·64	2·24	0·88	2·28	0·76
Sugars	—	—	5·30	—	5·30	—
Non-nitrogenous matter	47·94	15·47	40·10	37·41	41·38	26·44
Nitrogenous matter	25·62	5·00	23·43	3·81	24·52	4·41
	100·00	100·00	100·00	100·00	100·00	100·00
Nitrogen	4·10	0·80	3·75	0·61	3·92	0·71

As regards nutritive value, the seeds of the Jack Bean may thus be classed among the valuable leguminous seeds, and it is only natural that they should be used as fodder for live stock.

Naturally, when the Jack Bean is left to ripen, the leaves on the stem wither, and when the remainder of the crop is ploughed in the amount of fertilizing matter is not so large, especially as the seeds and shells have been gathered and are not returned to the soil; at the same time, if the seeds and shells are consumed by the beasts working on the plantation, there is only a redistribution of fertility, for if the manure produced be not used on the same spot, at least it will be returned to the soil of the estate.

From this point of view, then, it is useful to know the mineral composition of the pods, and we append tables showing the results of analyses in each case :--

PERCENTAGE COMPOSITION OF ASH.

	Seeds		Husks	
	I	II	I	II
Silica	3·79	0·38	2·63	2·65
Chlorine	1·67	1·88	1·56	1·21
Sulphuric acid	2·83	5·44	0·82	2·30
Phosphoric acid	22·20	23·66	1·22	2·92
Lime	6·76	7·06	7·79	9·67
Magnesia	7·40	8·61	1·43	2·57
Potash	41·95	38·60	50·05	47·95
Soda	4·44	4·50	5·73	0·97
Iron oxide	0·37	0·45	1·46	1·98
Carbonic acid, &c.	9·59	9·42	27·31	27·78
	100·00	100·00	100·00	100·00

PERCENTAGE COMPOSITION OF THE RIPE POD.

	Seeds			Husks		
	I	II	Average	I	II	Average
Silica	0·122	0·014	0·068	0·146	0·181	0·164
Chlorine	0·054	0·068	0·061	0·090	0·091	0·090
Sulphuric acid	0·072	0·196	0·134	0·047	0·157	0·102
Phosphoric acid	0·715	0·852	0·784	0·071	0·200	0·136
Lime	0·218	0·254	0·236	0·450	0·661	0·555
Magnesia	0·238	0·310	0·274	0·083	0·175	0·129
Potash	1·351	1·389	1·370	2·898	3·279	3·088
Soda...	0·143	0·162	0·152	0·331	0·067	0·200
Oxide of iron	0.012	0·016	0·014	0·085	0·135	0·110
Carbonic acid, &c.	0·295	0·339	0·317	1·579	1·894	1·736
Total mineral matter	3·220	3·600	3·410	5·780	6·840	6·310
Nitrogen	4·100	3·750	3·920	0·800	0·610	0·705

The following table gives the distribution of mineral elements in the seed and shell for 100 kilos of full pods (58 kilos seeds and 42 kilos shells).

From these figures the amount of matter withdrawn from the soil by the ripe pods may be calculated, and we see the necessity of using the empty husks to obtain farmyard manure.

One hundred kilos of full pods contain :—

	In the seeds	In the husks	In the whole pods
Silica ...	0·039	0·070	0·109
Chlorine...	0·032	0·038	0·070
Sulphuric acid ...	0·077	0·065	0·142
Phosphoric acid ...	0·454	0·057	0·511
Lime ...	0·136	0·233	0·369
Magnesia	0·158	0·054	0·212
Potash	0·794	0·297	2·091
Soda ...	0·088	0·084	0·172
Oxide of iron ...	0·008	0·046	0·054
Carbonic acid, &c.	0·192	0·706	0·898
Total mineral matter	1·978	2·650	4 628
Nitrogen	2·276	0·296	2·572
Dry matter	49·775	36·401	86·176

Numerous as the other advantagès of the Jack Bean are, its value as a green manure outweighs them all, and it is thus important to know the composition of the vegetable mass which may be returned to the soil after a few months' growth.

When planted between the rows in December or January, the Jack Bean is in full growth and flowers three months later; this is the time for ploughing in. The leaves are large and give good protection to the soil, but the amount of foliage, though comparatively large, is hardly in proportion with the general appearance of the plant, which is remarkable. When planted later its growth is more vigorous, the stems are less long and slender, being perhaps more stocky, and its growth is less rapid. However, provided it escapes too long a period of drought, this plant may be sown throughout the year.

In favourable circumstances, when planted along every second inter-row, the plant mass produced may easily be as much as 9,500 to 11,850 kilos per hectare. Evidently, when every row is sown the yield will be doubled, but in this

case care must be taken to pull every other row and plough it in in good time, to avoid depriving the small canes of too much light. In any case, if there is a danger of this happening through growth being too strong, whether the plantation is sown in successive or alternate rows, it is only necessary to slash along on each side of it to prevent the small canes from being overrun.

Directly the stems begin to bloom the pods rapidly increase in size and soon form a considerable proportion of the total weight of the crop; later on the weight of the pods exceeds that of the remainder of the plant.

A.—Sowing on December 12th, every alternate row; March 13th following, the total weight produced to the hectare was 12,300 kilos; the pods already developed forming 25 per cent. of the total crop.

B.—Same sowing; the weight of the crop per hectare on April 17th was 13,600 kilos; the majority of the leaves had fallen, but the seeds in their pods were well advanced and formed 67 per cent. of the total crop, that is to say, their weight exceeded that of the stems.

C.—Sowing on March 15th; harvest on August 14th following; the pods, now well developed, were badly attacked by grubs. They formed 70 per cent. of the total crop, which weighed 9,500 kilos (planting in alternate rows).

Analyses have been made of the whole crop, stems and pods. Although it cannot be said that beasts eat the stems of the Jack Bean with any relish, we nevertheless append the analysis from the point of view of fodder :—

	In 100 parts of natural substance			In 100 parts of dry matter		
	A	B	C	A	B	C
Water	80·92	76·87	74·20	—	—	—
Ash	1·72	1·15	2·10	9·02	5·00	8·15
Cellulose	5·50	7·36	5·83	28·83	30·82	22·61
Fat	0·78	0·55	0·70	4·09	2·38	2·71
Non-nitrogenous matter	8·20	10·86	12·20	42·96	47·92	47·60
Nitrogenous matter	2·88	3·21	4·88	15·10	13·88	18·93
	100·00	100·00	100·00	100·00	100·00	100·00
Nitrogen	0·46	0·50	0·78	2·45	2·15	3·03

PERCENTAGE COMPOSITION OF ASH.

	A	B	C
Silica	3·44	3·23	4·72
Chlorine	2·63	2·47	2·93
Sulphuric acid	3·49	3·60	1·30
Phosphoric acid	5·29	8·32	3·45
Lime	33·32	26·41	40·32
Magnesia	10·73	7·79	8·03
Potash	15·52	24·09	10·15
Soda	1·37	1·71	0·95
Oxide of iron	1·05	2·35	1·01
Carbonic acid, &c.	23·16	20·03	27·14
	100·00	100·00	100·00

	In 100 parts of natural substance			In 120 parts of dry matter		
	A	B	C	A	B	C
Silica	0·059	0·037	0·099	0·310	0·162	0·384
Chlorine	0·045	0·028	0·061	0·237	0·123	0·238
Sulphuric acid	0·060	0·041	0.027	0·315	0·180	0·106
Phosphoric acid	0·091	0·096	0·073	0·477	0·416	0·281
Lime	0·573	0·304	0·846	3·005	1·321	3·284
Magnesia	0·185	0·090	0·168	0·968	0·389	0·654
Potash	0·267	0·277	0·213	1·400	1·205	0·826
Soda	0·024	0·019	0·019	0·124	0·885	0·077
Oxide of iron	0·018	0·027	0·021	0·096	0·117	0·082
Carbonic acid, &c.	0·398	0·231	0·573	2·088	1·002	2·218
Total mineral matter	1·720	1·150	2·100	9·020	5·000	8·150
Nitrogen	0·460	0·500	0·780	2·410	2·150	3·030
Dry matter	19·080	23·130	25·800	—	—	—

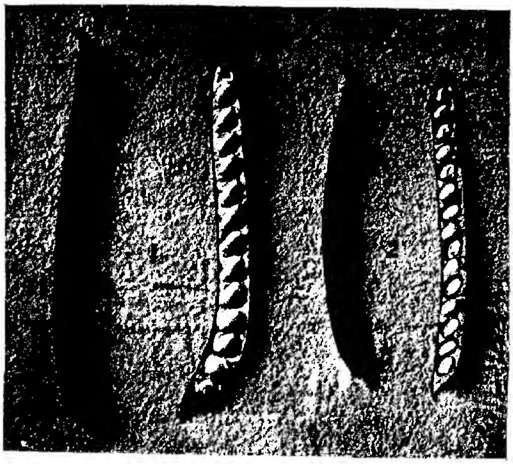
The composition of the crops from the respective sowings was as follows[1] :—

	A	B	C	Average
Silica	3·068	2·127	3·960	3·051
Chlorine	2·340	1·610	2·440	2·130
Sulphuric acid	3·120	2·358	1·080	2·193
Phosphoric acid	4·732	5·520	2·920	4·391
Lime	29·796	17·480	33·840	27·038
Magnesia	9·620	5·175	6·720	7·171
Potash	13·884	15·927	8·520	12·777
Soda	1·248	1·093	0·760	1·037
Oxide of iron	0·936	1·552	0·840	1·109
Carbonic acid	20·696	13·283	22·920	18·958
Total mineral matter	89·440	66·125	84·000	79·855
Nitrogen	23·920	28·692	31·200	27·937
Weight of crop	5,200 kilos	5,750 kilos	4,000 kilos	4,084 kilos
Dry matter	992 ,,	1,330 ,,	1,032 ,,	1,118 ,,

Neglecting other elements derived exclusively from the soil, this gives an average of 28 kilos of nitrogen, which is about the amount contained in 6 tons (metric) of farmyard manure with nitrogen in the proportion of 0·5 per cent.

[1] The figures given are for a crop from one arpent (=0·422 hectare).

The difference between the yields from the trial plantations at the station and those at Saint Hubert need occasion no surprise. In the experiments at the station only every second row was planted, whereas at Saint Hubert the whole area was utilized and the seeds were planted at intervals of 66 cm., thus raising the total of green matter to the hectare to 35½ to 38 tons.



[Photo by P. de Sornay.

FIG. 7. (1) Green-pod Jack Bean; (2) Dry-pod Jack Bean.

A trial made in our garden at Réduit enabled us to check the figure from Saint Hubert, and over an area of 18·75 square metres 68 kilos of green matter were obtained, which is proportional to 35½ tons to the hectare. These plants had fruited and a good number of pods had already been gathered.

In Bulletin No. 23 of the Hawaii Agricultural Experiments Station, the agricultural scientist, M. Krauss, gives results obtained from the Jack Bean at Hawaii. It yields

there from 38 to 47½ tons of green forage to the hectare. The best crop of seeds was 1,420 kilos to the hectare.

M. Krauss says that although they are only usually concerned with a single crop, a second crop has been attempted at this station, and but for the unfortunate attack of a rust common in peas was otherwise successful.

At Mauritius a number of landowners have extended this crop and several use the seeds as fodder for live stock. Such seeds are broken up, boiled, and then given to oxen, which do well on them.

At Dowsett and Pond's Dairy, Hawaii, they are used for milch-cows with excellent results, one part of green seed of canavalia with an equal proportion of sorghum.

In this country a great deal is made of *Canavalia ensiformis*. It resists drought well and may be grown between coffee, sisal, or rubber, &c.

M. Krauss states that nodules are always present on the roots in considerable numbers, but this is a point which has never been remarked in Mauritius, where, as a matter of fact, the nodules are rather sparse. We can assign no reason for their being so, but the plant thrives strongly and forms one of the best rotation crops we have.

M. Krauss gives the composition of the leaves of the Jack Bean. Beasts have no relish for this fodder, a fact which we have confirmed by a number of trials with milch-cows.

Water	76·81	per cent.
Ash	2·70	,,
Cellulose	6·36	,,
Fat	0·48	,,
Non-nitrogenous matter	8·44	,,
Nitrogenous matter	5·21	,,
	100·00	,,

These leaves contain the following fertilizing elements:—

Potash	0·65	per cent.
Lime	0·78	,,
Phosphoric acid	0·16	,,

In 1,000 kilos of this matter this amounts to:—

Nitrogen...	... ...	8·3 kilos.
Phosphoric acid	... ...	1·6 „
Potash ...	... ...	6·5 „
Lime ...	... ...	7·8 „

Although we are ignorant as to the conditions under which these samples were taken, we may state that the figures agree with others we have published which give for 1,000 kilos of natural substance:—

Nitrogen...	... ...	7·5 kilos.
Lime ...	... ...	7·5 „
Potash ...	... ...	6·9 „
Phosphoric acid	... ...	3·1 „

The proportion of phosphoric acid is higher in the crop from Saint Hubert, and the figures realized by M. Bonâme are slightly less, about 1 per cent., which is sufficient to show that these figures are very variable and depend to a large extent on the conditions of growth, climate, &c.

CAJANUS INDICUS (PIGEON PEA, CONGO PEA, NO-EYE PEA, AMBREVADE).

Cajanus indicus, which derives its name from the Indian word *Catjany*, is a native of India; it is a shrub with yellow flowers and trifoliate leaves. Some writers believe it to be rather a native of tropical Africa, but the etymology of the name is sufficient to show that such is not the case.

This member of the Leguminosæ differs from most others in that it is not a climbing plant, but a shrub, which may attain a height of about 3 metres. Two principal varieties are known, one with completely yellow (*C. flavus*) and the other with red and yellow flowers (*C. bicolor*).

This plant seems to have always been known in Mauritius and Réunion, and it was thought formerly that the improvement in the soil in which it was grown was due to its leaves, which fall and cover the ground. Cossigny, in 1802, recognized the value of the pigeon pea.

M. Desbassyns praised its use as a support for peas in a rotation.

It grows wild in India and Madagascar. According to Jacques and Herincq, *C. bicolor* was discovered in 1800, whereas the discovery of the *C. flavus* variety dates back as far as 1687.

The pigeon pea is a plant which lives for some years when suited as to soil and climate. In Mauritius it thrives well and needs no special method of cultivation. It is rather susceptible to stiff breezes and does better in a somewhat dry climate.

In sowing, two or three seeds are placed in holes about 1½ metres apart. The plants may then be left, no special tending, apart from cleaning the ground whilst the plants are young, being required.

After sowing, the seeds should be covered up with about an inch of soil. Germination takes place about a fortnight later, and care should be taken to keep the soil clean as long as the plants are not sufficiently developed to be able to withstand the attacks of weeds. From then till harvest they need no further attention. As regards this latter, it should not be delayed till the pods are too ripe.

After fruiting, towards the end of September, the plants are cut down to within a metre of the ground, and after the first rains growth recommences. This pruning is indispensable, or otherwise the plant would produce nothing the second year. By carrying it out every year the plants may be kept for three years. After this they fruit badly, and even the ripe stems sometimes succumb to the attacks of insects. In several countries, and particularly in Australia, it is considered preferable to renew the crop every year because of the difficulty of carrying out the pruning without damaging the shrubs, especially after the second year, when it is almost impossible to prune as one wishes. If the stems are used each year for fuel, we see no reason, especially for the first two years, why the crop should be re-sown.

[Sketch by P. A. Desruisseaux.

FIG. 8.—*Cajanus indicus* (Ambrevade or Pigeon Pea).
A, Inflorescence, three-quarters natural size. B, Green fruit, natural size.

The seed of the pigeon pea (*C. indicus*) is largely used as food in India, and forms the *dholl bravate* which is eaten there and also imported by Mauritius. This *dholl* is obtained from the two principal varieties, *C. flavus* and *C. bicolor.*

Appended are a few analyses of these seeds :—

	De Sornay		Raoul		Bonâme
Water	13·64	...	11·90	...	11·46
Ash	3·74		3·29	...	3·68
Cellulose	6·95	...	—	...	2·05
Fat	1·50	...	1·38	...	1·48
Sugars	8·29	...		...	5·00
Non-nitrogenous matter ...	46·70	...	63·43	...	56·52
Nitrogenous matter ...	19·18	...	20·00	...	19·81
	100·00	...	100·00	...	100·00

M. Balland gives analyses of seeds from different regions :—

	Guinea		Guiana		Madagascar		Réunion
Water	11·50	.	8·50	...	10·90	...	14·20
Ash	3·60	...	3·50	...	4·20	...	4·00
Cellulose	6·15	...	6·95	...	6·90	...	7·15
Fat	1·15	...	1·25	...	1·40	...	1·35
Non-nitrogenous matter ...	56·47	...	62·70	...	57·42	...	56·82
Nitrogenous matter ...	21·13	...	17·10	...	19·18	...	16·48
	100·00	...	100·00	...	100·00	...	100·00
Weight of 100 seeds, grm.	10·00	...	11·25	...	9·61	...	16·24

Professor Church obtains the following figures from seeds harvested in India and intended for human consumption :—

	Shelled		Unshelled
Water	10·5	...	13·3
Ash	3·0	...	3·8
Cellulose	1·2	...	7·5
Fat	2·1	...	2·6
Starch	60·9	...	55·7
Nitrogenous matter	22·3	...	17·1
	100·0		100·0

This is a rich food; as can be seen, the nutritive ratio is 1 :3, while the nutritive value is 80 per cent.

The pods may be used as fodder, which bears out what M. Bonâme said in his report in 1897, where there is an analysis of the pods of *C. indicus.*

Water	11·44 per cent.
Ash	4·00 ,,
Cellulose	25·00 ,,
Fat	0·28 ,,
Non-nitrogenous matter	54·10 ,,
Nitrogenous matter	5·18 ,,
	100·00 ,,

Dr. Leather, Chemist to the Indian Government, gives an analysis of seeds, leaves and husks gathered from the threshing floor.

	In 100 parts seeds	In 100 parts leaf and husk from threshing floor (chaff)
Water	10·13	8·81
Ash	3·78	11·87
Cellulose	5·78	19·23
Fat	1·34	4·40
Non-nitrogenous matter ...	59·10	43·25
Nitrogenous matter	19·87	12·44
	100·00	100·00
Nitrogen	3·18	1·99
Protein nitrogen	2·81	1·76

The proportion of phosphoric acid in these seeds varies in different regions, as shown by M. Balland's analyses:—

Madagascar	0·94 per cent.
Malaimbandy	0·82 ,,
Manisana	1·13 ,,
Vatomandry	0·69 ,,
New Caledonia	1·14 ,,
Réunion	1·15 ,,

C. indicus is known by a number of names, according to the different countries in which it is cultivated, *e.g.*, pigeon pea, no-eye pea, Congo pea, Angola pea, ambrevade, &c. It is now very widely distributed in nearly all tropical countries.

In Mauritius and the Mascarene Isles it is known as *ambrevade*. On some estates in the North and South of Mauritius it is sown fairly widely as a rotation crop. The seeds are used for human consumption as well as for fodder. Unfortunately, it is attacked by a caterpillar which devours the husks, and in some portions of the island, particularly in high situations, it is quite impossible to grow this vegetable.

The thought suggests itself that, as a green manure, it cannot possibly give such good results as the trailing Leguminosæ, because, in addition to the seeds being removed, the stems are used for fuel. Like those of a number of shrubs, its roots penetrate fairly deeply into the soil, and mineral elements are taken not only from the arable layer but also from the subsoil.

During growth, leaves fall on the soil in great numbers, and by their slow decomposition give rise to humus.

The following is the composition of the stems and leaves of this plant, according to our analyses:—

	In 100 parts dry matter	In 100 parts natural substance
Water	—	54·50
Ash	4·10	1·86
Nitrogen	1·41	0·64

	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of natural substance
Silica	7·66	0·313	0·142
Chlorine	1·25	0·051	0·023
Sulphuric acid	5·00	0·205	0·093
Phosphoric acid	13·82	0·567	0·257
Lime	18·46	0·757	0·343
Magnesia	6·63	0·272	0·123
Potash	27·74	0·137	0·516
Soda	2·08	0·085	0·039
Oxide of iron	4·85	0·199	0·090
Carbonic acid, &c.	12·51	0·514	0·234
	100·00	4·100	1·860

Thus 18·6 kilos of mineral matter are extracted from the soil by 1,000 kilos of stems and leaves. The following are the proportions in which the chief elements are present:—

Lime	3·43 kilos
Magnesia	1·23 "
Potash	5·16 "
Phosphoric acid	2·57 "

M. Krauss, in Bulletin No. 23 of the Hawaii Agricultural Experiments Station, gives the composition of the forage portion of the plant as:—

Water	70·00	per cent.
Ash	2·64	,,
Cellulose	10·72	,,
Fat	1·65	,,
Non-nitrogenous matter	7·88	,,
Nitrogenous matter	7·11	,,
	100·00	,,

Mineral elements are found in the following proportions:—

Potash	0·90	per cent.
Lime	0·42	,,
Phosphoric acid	0·25	,,

1,000 kilos contain:—

Nitrogen	11·3	kilos.
Phosphoric acid	2·5	,,
Potash	9·0	,,
Lime	4·2	,,

Although the utilization of seeds and stems means the removal of fertilizing matter, on the other hand this loss is balanced by the profit on the seeds, which still fetch a fair price.

In dry localities we have been informed that at times the crops have been so abundant that the seeds have been used as fodder for horses and other animals; thus any loss occasioned by such prolific harvests is made good in another way.

According to information we have been able to obtain, a planting of pigeon pea (three seeds in each hole) may produce during the three months of floresccence and fructification 2·5 lb. of husked seeds. When dried these seeds only represent a little over 1 lb.

From these data it can be seen that a hectare (with the hole 1½ metres (5 ft.) apart each way) may contain about 3,800 holes, and the yield from the plants would thus be 4,700 kilos to the hectare, or, say, 2,350 kilos of dry seeds.

In Hawaii, where this plant seems to be very popular, the same yield is obtained, *i.e.*, 4,700 kilos of seed to the hectare and a larger amount the second year.

Sold on the fields at 5d. a kilo the yield from one hectare would be worth 470 rupees (£31 6s. 8d.) These figures are only relative and may vary according to conditions of cultivation, fruiting, &c.; for instance, in India the yield in dry seeds varies from 1,150 to 4,750 lb. per hectare, while in Australia 1¼ ton is considered an average yield to the acre.

After harvesting, the leaves may be given in their green state as fodder to live stock and are consumed readily.

[*Photo by Desruisseaux.*

FIG. 9.—Plants of *Cajanus indicus* (Pigeon Pea) sheltering a vanilla plantation in Anjouan.

According to Dr. Watt, the stems of *C. indicus* may be used for thatching roofs and manufacturing baskets. Dr. Roxburg says the wood forms an excellent fuel, and Birdwood states that the stems are used in the manufacture of gunpowder in Government works at Mazagon.

In Madagascar, the leaves are used in rearing silk-worms, and in the north of Bengal Cajanus serves for feeding lac insects.

Evidently, then, this plant has a number of different uses, and we recommend its cultivation not only as a manurial crop, but also as a food plant; in localities where it fruits abundantly and the pods are not damaged by insects it can be of considerable use both to man and beast.

In conclusion, we will append a few notes on this plant made in the Comoros by M. Advisse Desruisseaux.

The pigeon pea is grown on the same field and at the same time as rice, maize, mungo beans, cowpeas, sweet potatoes, and banana plants. After the other plants have been harvested it is allowed to remain either alone or with sweet potatoes for two or three years. It is pruned annually, in November, to within 80 cm. or 1 metre of the ground. In Anjouan, where it is cultivated by natives, it lives and fruits for five years.

Planters frequently grow it in young vanilla plantations and allow it to fruit, when the nitrogenous and mineral matters contained in the soil are transferred to the fruit. It is more advisable to pull the stalks at flowering, or, better still, destroy the flowers themselves (April, May, June) and leave the plant till December—January, pulling it at the commencement of the rains.

The pigeon pea is attacked at Anjouan by two of the Lepidoptera, a white *Pieris* of fair size, and a little bluish *Terias*. The latter undergoes its transformation into a chrysalis in the stem, where it causes swellings which render the plant incapable of offering much resistance to the wind.

An *Agromyza* similar to that of the bean (Mauritius, Réunion) attacks the cortex of the young plant, which, however, offers a sturdy resistance.

A *Bruchus* lays its eggs on the ovary. The larva penetrates the seed and the metamorphosis into the perfect insect

takes place about a month after harvest. This beetle causes a large amount of damage among seeds stored in their husks. It is a good plan to shell the pods and store the seeds in hermetically sealed vessels with a sufficient amount of bisulphide of carbon to suffocate the larvæ without harming the seeds.

Although there is but one species of *Bruchus*, specimens of different sizes are found emerging from the seeds, the reason being that there are often a number of insects in one seed, the first to complete their metamorphosis find sufficient nourishment for their normal development, while those coming later remain small through its absence.

We may add that in Mauritius, in high situations, *Lycæna boetica* and *L. telicanus* both work absolute havoc among pigeon peas. Of these two Lepidoptera *L. boetica* is the more harmful to *Cajanus indicus*. According to observations by M. Maurice Girard on *Lycæna bœtica*, the female lays her eggs on the pods, and the caterpillar, which is more or less dark green in colour with its back striped with red, lives on the seeds, passing from one pod to another and blocking up the aperture through which it enters. This species also devours the pods of the bladder-nut tree (*Colutea arborescens*), and in default of this it attacks green peas.

CICER ARIETINUM (CHICK PEA).

The chick pea is cultivated in India, being employed as fodder for horses in the north and west. A considerable amount is exported. This plant thrives well in tropical countries where the temperature is not too high and the rainfall is moderate.

This plant has the advantage of not causing overheating or excitement in animals.

Appended is an analysis by Sagot of seeds harvested in the tropical zone:—

Water	10·80 per cent.
Ash	3·12 ,,
Fat	4·56 ,,
Starch	62·20 ,,
Nitrogenous matter	19·32 ,,
	100·00

In Balland's work, "Les Aliments," is a series of analyses of chick peas from Algeria, Tunis, Madagascar, &c., which show the nitrogenous matter to vary from 15·96 to 21·14. The average weights of 100 seeds are:—

Algeria	41·60 grm.
Tunis	40·38 ,,
,, ...	33·80 ,,
Madagascar	46·50 ,,

[*Sketch by P. A. Desruisseaux.*

FIG. 10. Stem and fruits of *Cicer arietinum* (Gram).

A few trials made in Mauritius with the large edible chick pea gave rather unsatisfactory results. This plant is one which could be very useful in a mixed cultivation, but is destroyed by a number of enemies.

To begin with, hares sever the young plants; also an aphis attacks the roots of the adult, which quickly withers;

and finally, a green caterpillar empties all the pods, the damage done by the latter being sometimes so extensive as to reduce the harvest over a certain area to practically *nil*.

We append our analysis of the proximate and mineral composition of the seeds:—

Water	11·80 per cent.
Ash	2·75 "
Cellulose	12·95 "
Fat	3·70 "
Non-nitrogenous matter	50·74 "
Nitrogenous matter	18·06 "
	100·00

These figures are very similar to those Sagot gives for the ordinary Indian seed.

Its mineral composition shows, as in most leguminous plants, high proportions of potash and phosphoric acid, those of magnesia and lime remaining about the same.

	In 100 parts of pure ash	In 100 parts of seeds
Silica	5·88	0·16
Chlorine	5·32	0·15
Sulphuric acid	3·14	0·08
Phosphoric acid	15·51	0·42
Lime	9·10	0·25
Magnesia	7·70	0·21
Potash	38·48	1·05
Soda	4·65	0·13
Oxide of iron	2·09	0·06
Carbonic acid, &c.	8·13	0·24
	100·00	2·75

The chick pea makes an excellent fodder, and we give the composition of the plant, both in its green and dry states.

The dry pods give a proportion of 23·6 per cent. husks and 76·4 per cent. seeds.

The roots may be detached, as, owing to their large proportion of cellulose, they only yield a coarse nutriment with small nitrogen content.

Green stalks with flowers and fruit:—

	In 100 parts of dry matter	In 100 parts of natural substance
Water	–	71·90
Ash	7·71	2·16
Cellulose	40·55	11·39
Fat	3·68	1·03
Sugars	4·00	1·12
Non-nitrogenous matter	34·31	9·67
Nitrogenous matter	9·75	2·73
	100·00	100·00
Nitrogen	1·56	0·44
Protein nitrogen	1·19	0·33

The dried stems bore 51 per cent. of pods; the following is the composition of dried stalks and fruit:—

	Per cent.
Water	11·15
Ash	7·80
Cellulose	35·85
Fat	3·90
Sugars	2·64
Non-nitrogenous matter	32·10
Nitrogenous matter	6·56
	100·00
Nitrogen	1·04

The roots, after being washed and dried, gave the following composition:—

	Per cent.
Water	10·90
Ash	4·00
Cellulose	45·75
Nitrogen	0·45

It is unfortunate that no more favourable conditions can be found in Mauritius for the growth of this plant, as it could be sown in two rows between canes without harming the latter in any way, and the seeds would provide a useful fodder.

The Agricultural Ledger, 1903, No. 7, gives the content of nutritive elements in seeds, husks and leaves from the threshing floor:—

	In 100 parts of seed	In 100 parts of leaves and husks
Water	9·98	8·41
Ash	3·15	13·11
Cellulose	6·40	26·71
Fat	4·39	2·27
Non-nitrogenous matter	57·94	45·85
Nitrogenous matter	18·14	3·65
	100·00	100·00

In India this pea is cultivated over an area of more than four million hectares. The yields show considerable variation according to locality and conditions of cultivation.

On unirrigated lands the yield is less, and supposing the average yield of the vast area planted to bè 710 kilos per hectare, the limits for unirrigated land will be 485 kilos, 745 kilos, 950 kilos, 1,005 kilos; and for irrigated land 745 kilos, 1,125 kilos, and 1,420 kilos. These differences depend on the more or less favourable conditions in the different localities where the plant is grown.

This pea is used in India in different forms as food for both man and beast. When roasted the seeds are quite agreeable in flavour; after having been boiled to remove the seed-coat they are prepared in a number of ways; and when ground they are used to prepare sweet dishes or biscuits. The young shoots are eaten as a vegetable, and the plants are also used in the preparation of vinegar.

Large quantities of this pea are exported from India annually, some occasionally to Mauritius, and England as well.

In 1906-7 the amount exported was about 84,658 tons, of a value of 3,231,744 rupees.

M. Aug. de Villèle, Agricultural Chemist, published in 1904 the following facts in the "Revue Agricole de la Réunion":—

The gram crop at Saint Gilles-les-Haut (Saint Paul) yielded per hectare:—

Fallen leaves	1,230·88 kilos
Seeds	3,780 "
Husks	944·05 "

IN 100 PARTS

	Stems and leaves	Seeds	Husks
Water ...	9·44	10·00	5·73
Mineral matter ...	6·45	3·00	10·56
Organic matter ...	84·11	87·00	83·71
Lime	1·248	0·431	1·229
Potash ...	1·876	1·084	1·997
Magnesia ...	0·417	0·248	0·269
Phosphoric acid	0·097	0·645	0·068
Sulphuric acid ...	0·294	0·298	0·150
Nitrogen ...	0·840	3·010	0·700

MATTER ABSTRACTED PER HECTARE ($2\frac{1}{2}$ ACRES).

	Stems and leaves	Seeds	Husks	Total
Mineral matter ...	79·39 ...	113·40 ...	54·09 ...	246·88
Lime	16·291 ...	15·361 ...	11·602 ...	43·255
Potash	21·980 ...	68·191 ...	19·582 ...	109·756
Magnesia ...	5·130 ...	9·374 ...	2·540 ...	19·044
Phosphoric acid ...	1·193 ...	24·003 ...	0·641 ...	25·837
Sulphuric acid ...	4·130 ...	11·260 ...	1·410 ...	16·980
Nitrogen ...	10·339 ...	113·778 ...	6·508 ...	130·980

PROPORTIONS OF MINERAL MATTERS IN THE DIFFERENT PORTIONS OF THE PLANT.

	Seeds 100 kilos	Husks 24·94 kilos	Stems 32·53 kilos	Total 157·48 kilos
Lime	0·43 ...	0·30 ...	0·40 ...	1·14
Potash	1·08 ...	0·49 ...	0·58 ...	2·16
Magnesia	0·24 ...	0·06 ...	0·13 ...	0·45
Phosphoric acid ...	0·04 ...	0·01 ...	0·03 ...	0·69
Sulphuric acid ...	0·29 ...	0·03 ...	0·09 ...	0·43
Nitrogen	3·01 ...	0·17 ...	0·27 ...	3·45

CROTALARIA.

Crotalaria derives its name from the Greek *krotalon*, a rattle, a reference to the sound emitted by the fruit when shaken or disturbed. There are a number of varieties of this plant, which is a native of India, America, Madagascar, Mauritius and Bourbon, the Antilles, &c.

It has established itself in the majority of tropical countries and is to be encountered more or less everywhere. It reaches its greatest importance in India, where huge fields are to be seen covered with wild Crotalariæ.

According to Bojer a number of species of Crotalaria are natives of Mauritius, *e.g.*, the blue Crotalaria.

The species of Crotalaria are very numerous and would make an excessively long list; we may just mention the fact that some are very ornamental.

The grower, who never wishes to miss an opportunity of enriching his soil, should ascertain which of the plants in this large family is best adapted to his particular type of cultivation. In that of the sugar-cane Crotalaria is particularly useful for ploughing in as green manure. This plant, which reaches the height of about 4 ft., is of very

erect growth and but little branched at the base. It may easily be grown between canes, forming a plant mass

[Photo by G. Réhaut.

FIG. 11.—*Crotalaria retusa.* Stems, flowers and fruit.

probably superior to that to be obtained from any other Leguminosæ.

In India and Ceylon, Crotalaria is greatly valued as green manure. *Crotalaria juncea* and *C. quinquefolia*, which are found there, furnish a fibre called Indian hemp

[*Photo by G. Kehaut.*

FIG. 12.—*Crotalaria fulva*. Stems with flowers.

or Sunn hemp. It is of fair strength and is used in the manufacture of paper and fabrics.

As this plant is not relished by animals and the seeds are no good for food, it can only be used as a green manure.

When planted between the rows, this shrub, during floresccnce, may yield an average of 33 to 35½ tons of green matter to the hectare, which, counting 0·31 per cent. of nitrogen, is equivalent to 102 to 109 kilos over that area.

M. Bonâme has obtained excellent results from a number of trials at the Agronomic Station. The plant develops splendidly without the least injury to the small canes. Three or four seeds are sown together in holes from 50 to 60 cm. apart. When the plants are from 10 to 20 cm. high, the more weakly ones are weeded out and one or two left.

Among all the varieties tested, those succeeded best which were most acclimatized. This is usually the case; species which are indigenous or have been cultivated for a number of years are more hardy than varieties newly introduced, which, thougl. they may have special qualities of their own, are nevertheless less useful because less established.

According to M. Bonâme, three different cultivations gave, for a crop in full flower when ploughed in, the following results:—

A.—Full cultivation, yield per hectare ...	32,220 kilos
B.—Cultivation between canes, every alternate row ...	11,680 ,,
C.— ,, ,, ,, ...	7,110 ,,

PERCENTAGE COMPOSITION OF ASH.

	A	B	C
Silica ...	4·70	4·73	1·96
Chlorine ...	3·42	4·70	3·90
Sulphuric acid ...	1·89	2·17	0·61
Phosphoric acid ...	4·63	5·13	3·71
Lime ...	27·47	28·79	43·60
Magnesia ...	9·03	9·18	5·25
Potash ...	21·10	21·35	10·26
Soda ...	1·30	2·16	1·26
Oxide of iron ...	1·63	1·30	0·48
Carbonic acid, &c. ...	24·83	20·49	28·97
	100·00	100·00	100·00

COMPOSITION OF 100 KILOS OF NATURAL SUBSTANCE.

	A	B	C
Silica	0·091	0·063	0·037
Chlorine	0·066	0·063	0·073
Sulphuric acid	0·036	0·029	0·012
Phosphoric acid	0·089	0·069	0·070
Lime	0·530	0·386	0·820
Magnesia	0·174	0·123	0·098
Potash	0·407	0·286	0·193
Soda	0·025	0·029	0·023
Oxide of iron	0·032	0·017	0·009
Carbonic acid, &c.	0·480	0·275	0·545
Total mineral matter	1·930	1·340	1·880
Water	77·50	82·80	79·30
Dry matter	22·50	17·20	20·70
Nitrogen	0·44	0·32	0·36

PERCENTAGE COMPOSITION OF DRY MATTER.

	A	B	C
Silica	0·409	0·369	0·178
Chlorine	0·298	0·367	0·355
Sulphuric acid	0·164	0·169	0·056
Phosphoric acid	0·403	0·400	0·338
Lime	2·389	2·246	3·968
Magnesia	0·786	0·716	0·478
Potash	1·836	1·665	0·933
Soda	0·113	0·168	0·115
Oxide of iron	0·142	0·101	0·043
Carbonic acid, &c.	2·160	1·599	2·636
Total mineral matter	8·700	7·800	9·100
Nitrogen	1·970	1·860	1·730

According to these results, the sum of fertilizing matters contained in the total harvest gives, with the different weights obtained from each harvest, the following figures :—

TOTAL OF FERTILIZING MATTER.[1]

	A	B	C
Silica	12·376	3·129	1·110
Chlorine	8·976	3·112	2·190
Sulphuric acid	4·896	1·433	0·360
Phosphoric acid	12·114	3·392	2·100
Lime	72·080	19·046	24·600
Magnesia	23·664	6·071	2·940
Potash	55·352	14·119	5·790
Soda	3·400	1·425	0·690
Oxide of iron	4·352	0·857	0·270
Carbonic acid, &c.	65·270	13·560	16·350
Total mineral matter	262·480	66·144	56·400
Dry matters	3,060 kilos	848 kilos	621 kilos
Nitrogen	59·840	15·773	10·800
Weight of the green crop	13,600 kilo	4,930 kilos	3,000 kilos

[1] The figures are for the crop from one arpent (0·422 of a hectare).

Growers in India have long been aware of the value of *Crotalaria juncea* for restoring soil fertility. When used as a green manure it is cut at the end of two or two and a half months and ploughed in.

The varieties already mentioned are not the only ones capable of being utilized. Many others become rapidly acclimatized and have the further advantage of being able to grow in poor soils.

This leguminous plant might certainly be used as an unmixed crop, and when species are chosen with a well-developed leaf system, picking and ploughing in present no difficulty.

CYAMOPSIS PSORALOIDES.

Cyamopsis psoraloides is a species belonging to the Phaseoleæ, cultivated for the sake of its pods. They are eaten in the green state when young and tender. The stems and leaves serve as fodder for beasts. The seeds are of little value. The following is an analysis by Dr. J. W. Leather in the *Agricultural Ledger*:—

Water	9·83	per cent.
Ash	3·85	,,
Cellulose	8·08	,,
Fat	2·81	,,
Non-nitrogenous matter	46·00	,,
Nitrogenous matter...	29·43	,,
	100·00	
Nitrogen	4·71	,,
Nitrogen as proteins	4·36	,,

DESMODIUM TORTUOSUM.

In the sub-tropical portions of the United States this member of the Leguminosæ is greatly valued as fodder. Under the name of "Florida beggar-weed" it grows wild in the Southern States, yielding a fodder of some value and also serving as green manure. It may attain a height of 2 to 3 metres, and though its stems then become woody

they are devoured without difficulty by all kinds of cattle. It is also used in regenerating spent soils and restoring their fertility.

[Photo by G. Réhaut.

FIG. 13.—*Desmodium triquetrum.* Stems, flowers and fruit.

As with all Leguminosæ, sowing is carried out at the commencement of the rainy season. The seeds are broadcasted and covered, if possible, with a light layer of soil.

Under favourable conditions the plant develops very strongly; after harvest the stems bud anew and the plant resows itself by means of the fallen seeds.

This plant is worth propagating even when better are available, as it may be turned to account in waste and neglected soils, where usually one finds only useless weeds. It may be grown in all tropical countries, and makes a useful fodder.

Several tests have been carried out at the Agronomic Station in Mauritius, and its yield has been ascertained to be as high as 59,230 kilos to the hectare.

The stems have only a low nutritive value and constitute rather a coarse fodder, containing from 50 to 55 per cent. cellulose; it is only gradually that beasts can acquire any relish for such food, unless it be mixed with a fair proportion of leaves and branchlets or other food.

M. Bonâme gives the composition to be as follows:—

<table>
<tr><th></th><th colspan="2">Composition of leaves</th><th colspan="2">Composition of stems</th></tr>
<tr><th></th><th>Leaves</th><th>Dry matter</th><th>Stems</th><th>Dry matter</th></tr>
<tr><td>Water</td><td>77·80</td><td>—</td><td>70·30</td><td>—</td></tr>
<tr><td>Ash</td><td>1·94</td><td>8·72</td><td>1·06</td><td>3·58</td></tr>
<tr><td>Cellulose</td><td>6·32</td><td>28·45</td><td>15·77</td><td>53·10</td></tr>
<tr><td>Fat</td><td>0·26</td><td>1·13</td><td rowspan="2">11·48</td><td rowspan="2">38·64</td></tr>
<tr><td>Non-nitrogenous matter</td><td>9·37</td><td>42·20</td></tr>
<tr><td>Nitrogenous matter</td><td>4·31</td><td>19·50</td><td>1·39</td><td>4·68</td></tr>
<tr><td></td><td>100·00</td><td>100·00</td><td>100·00</td><td>100·00</td></tr>
</table>

The amount of nitrogenous matter in the form of proteins in the leaves, when in their normal state, is 3·98 per cent. or 92 per cent. of the total quantity of nitrogenous matter.

The proportions of mineral matters in 100 parts of dry matter have been determined and are shown in the appended table:—

	Leaves	Stems
Silica	0·816	0·097
Chlorine	0·065	0·013
Sulphuric acid	0·152	0·083
Phosphoric acid	0·543	0·211
Lime	2·337	0·759
Magnesia	0·502	0·260
Potash	2·231	1·217
Soda	0·035	0·018
Oxide of iron	0·035	0·018
Carbonic acid, &c....	2·004	0·904
	8·720	3·580
Nitrogen	3·120	0·750

In relating these figures to the dry matter of the total harvest per hectare, it is seen that the proportion of total mineral substances reaches 711 kilos for the leaves and 159 kilos for the stems.

If only the principal elements of the harvest are taken into consideration we should obtain :—

	Leaves	Stems	Total
Phosphoric acid... ...	4·425	0·936	5·361
Lime	19·051	3·364	22·415
Magnesia	4·089	1·151	5·240
Potash	15·816	5·397	21·213

We have had the opportunity of analysing other samples of *Desmodium triflorum,* which had just begun to wither. This plant was discovered in the East Indies in 1732. It has stems about 30 cm. high, with leaflets spotted on top with white, purple flowers, &c. It is found growing wild to a certain extent everywhere and beasts graze it along with other herbs.

	In 100 parts of dry matter	In 100 parts of natural substance
Water	—	64·60
Ash	7·28	2·57
Cellulose	35·00	12·39
Fat	2·60	0·92
Sugars	2·65	0·93
Non-nitrogenous matter ...	38·91	13·79
Nitrogenous matter	13·56	4·80
	100·00	100·00
Nitrogen	2·17	0·77

Its mineral composition is as follows:—

	In 100 parts of ash	In 100 parts of dry matter	In 100 parts of natural substance
Silica ...	17·34	1·262	0·445
Chlorine...	0·97	0·070	0·025
Sulphuric acid	1·30	0·094	0·033
Phosphoric acid	7·80	0·568	0·200
Lime ...	23·39	1·703	0·601
Magnesia	2·88	0·209	0·074
Potash ...	19·50	1·419	0·501
Soda ...	1·10	0·080	0·028
Oxide of iron	4·72	0·343	0·121
Carbonic acid, &c.	21·00	1·532	0·542
	100·00	7·280	2·570

There are a number of other varieties of Desmodium, which are to be found growing wild in tropical countries. The majority are natives of India, with the exception of *D. umbellatum*, which was discovered in Madagascar in 1801.

All who have had occasion to visit the Colonies have been struck by the fine vegetation of these papilionaceous Leguminosæ, herbaceous and undershrub-like in character. They are forage crops, of great value as food for cattle. In the tropical regions of Asia, Africa, and America is found a variety of special interest, *D. triflorum*. This is a perennial herb, of tufted growth and with abundant foliage, which may be used in place of clover in countries too hot for this latter; the analysis we have already given. The botanist, Roxburgh, has already drawn the attention of agriculturists to this species, which forms fine natural prairies in India and is particularly relished by cattle. According to Colonel Drury, it thrives in all soils.

In North America use is made of a number of species of Desmodium, such as *D. canadense*, *D. acuminatum*, and *D. nudiflorum*. The first species is said to have been discovered in Canada in 1640.

According to Lanessan, a Desmodium of undetermined species exists in New Caledonia, the flowers of which contain a blue colouring matter analogous to that of the indigo

plants, which is used by the natives, after treatment with lime, to dye stuffs.

There are numerous species of Desmodium, and several are natives of Mauritius and the Mascarenes: *D. cæspitosum*, *D. mauritianum*, *D. Scalpe*, *D. oxybracteum*, *D. triflorum*, *D. heterophyllum*, &c. The most widely distributed is *D. cæspitosum*, which grows throughout the islands of Africa, its common name being "clover." Both Bojer, in his "Hortus Mauritianus," and Baker, in his "Flora of Mauritius," give twenty-two species of Desmodium. Unfortunately, it is not cultivated in any way, although it might be very useful on waste land. It resists drought well and could be used as fodder after the sugar season. It is to be hoped that much greater use will be made of the resources offered by our colonial plants.

DOLICHOS BIFLORUS.

Dolichos biflorus is an Indian plant, yielding a food seed which is cheaper than gram or oats. Its Indian name is "kulthi," and its nutritive value is greater than that of ordinary gram.

Consignments have been made to Mauritius, but have not been repeated, the sale having been difficult, no doubt on account of unfamiliarity with this seed.

It is also cultivated as a forage crop, and Robertson relates that, in two months, during a very hot period, with a minimum of rain, he produced from 1 to 2 tons of fodder. Its easy growth affords a good recommendation, the more so as it thrives in all seasons and needs but little rain for its germination and early growth.

It is but little cultivated in the low provinces of India. Sowing is carried out in October or November if a seed harvest is required, but, when needed for fodder after a couple of months' growth, it is sown in June, August, and November, three times in succession.

According to Mukerji, the yield per hectare in seed is 355 kilos, and in forage $11\frac{3}{4}$ tons, according to which of the two classes of crop is taken. These figures vary with the locality, and may reach a total, for the seeds, of 1,420 kilos to the hectare.

The area planted in India is more than ten million acres. This plant is in much demand as fodder. The peas are boiled whole and are given to the animals when cool.

The following is an analysis made by M. Bonâme in 1897 :—

	Sagot	Bonâme
Water...	11·30 per cent.	10·80 per cent.
Ash	3·34 ,,	3·90 ,,
Cellulose	— ,,	6·35 ,,
Fat	0·87 ,,	0·60 ,,
Non-nitrogenous matter	61·02 ,,	56·73 ,,
Nitrogenous matter	23·47 ,,	21·62 ,,
	100·00	100·00

According to the *Agricultural Ledger*, *Dolichos biflorus* has the following composition :—

	Seed.	Leaves and husks from threshing floor
Water	8·82	5·60
Ash	5·76	8·85
Cellulose ...	4·13	28·01
Fat	0·80	2·63
Non-nitrogenous matter	58·18	48·10
Nitrogenous matter	22·31	6·81
	100·00	100·00
Nitrogen ...	3·57	1·09
Nitrogen as protein	2·91	0·84

In India it is known as "horse gram," and is used principally for feeding horses. It is cultivated for its seeds, and Indians occasionally eat them like other vegetables, but they are hard and indigestible.

DOLICHOS BULBOSUS (MANIOC PEA, YAM BEAN).

Dolichos bulbosus, or *Pachyrhizus angulatus*, is known as manioc pea or yam bean.

According to Rumphius, this plant is a native of the Philippines and is cultivated in India and the Moluccas.

In the book by Guillemin, Perrottet, and Richard, "Floræ Senegambiæ tentamen" (vol. i), we read the following:—

"Its importance as a food plant induced us to convey it from Java to Bourbon, Cayenne, and to the Natural History Museum in Paris." This document dates from 1820, and Perrottet, in vol. x of the "Bibliothèque physico-économique" (1821), gives a description.

The plant then has flourished in Réunion for nearly a century, and judging from the proximity of the two countries it may be inferred that these peas were introduced into Mauritius from that island.

The manioc pea is perennial as regards its bulbs, and annual as regards its stems. It thrives in all kinds of soils without any attention. Its leaves are trifoliate and very broad, one of its most clearly marked external characters. This pea spreads a great deal, it covers the ground rapidly, and if planted in proximity to other Leguminosæ grows at their expense, concealing them almost completely.

The flowers are bluish violet and in terminal clusters. The pods are characterized by the regular swellings caused by the seeds, which are rather flat.

Particular interest is lent to this plant by the tubercles produced on the root. M. Bonâme has calculated that the yield in tubercles may be as much as 95 tons to the hectare. Each mother stem gives rise to a bulb which increases in size as it grows older, and eventually reaches considerable dimensions.

A plant raised under good conditions at the Agronomic Station produced, after two years' growth, a tubercle of 18 kilos.

Contrary to the case of the seeds, which it is thought can only be utilized after a certain amount of trouble, the tubercles are in great request for food purposes in certain countries. In a note of particular interest, published by M. Chalot in "l'Agriculture Pratique des Pays Chauds," we read that its feculent and fleshy roots are valued very highly in some

countries, and another note by M. Perrottet, containing high praise of this tubercle, leads us to believe that it may bear comparison with the potato. Such is not our opinion, for although a few small populations may consider it a

[Photo by P. de Sornay.

FIG. 14.—*Dolichos bulbosus* (Manioc Pea).

delicacy, it cannot be admitted that this plant can ever supersede the potato. With the best will in the world we have never been able to discover in it anything that might be termed delicious. Eaten raw its fibres are difficult to

chew, and notwithstanding long periods of cooking, the tubercles are never sufficiently done to be capable of being eaten like the potato. We consider it must be a question of personal taste, and until we have received proofs to the contrary we cannot think that its consumption will ever become general.

M. Teissonnier has published a note on this plant, which was introduced into French Guinea by the efforts of the officials of the Colonial Gardens of Nogent-sur-Marne, and M. Chalot, who gives an account of the article, states that the author advises pinching off the stems from those roots which are intended as food. The first pinching off should be carried out when the plants are about 30 cm. high, and the second when the stems are on a level with the props which support them. The object of these nippings and the suppression of the flowers is to prevent the absorption of sap by useless portions of the stems, or by the flowers, to the detriment of the bulbs. M. Teissonnier obtained in this trial 19 tons of edible tubercles to the hectare.

He says that in Mexico it is cultivated on a large scale. As has been mentioned already, this plant adapts itself to nearly all soils, but the most favourable condition for its growth is a light and sandy soil. It is sown at the commencement of the rains, and owing to its prolific growth should be spaced out at intervals of one metre. If the use of this tubercle as human food is limited, its value as fodder is correspondingly great.

Its immense productivity at practically no cost is one cause of its success. It is true that it contains a great deal of water, but that does not prevent its use as a supplementary ration. The tubercles may be harvested when growth has ceased and the plant has withered. In dry localities they may be left in the soil and withdrawn as they are needed, but this period should not exceed two months and a half to three months. Its composition is as follows:—

8

	In 100 parts of dry matter	In 100 parts of tubercles
Water	—	84·50
Ash	3·61	0·56
Cellulose	5·03	0·78
Fat	0·50	0·08
Sugars	32·45	5·03
Non-nitrogenous matter ...	47·77	7·40
Nitrogenous matter ...	10·64	1·65
	100·00	100·00

The limits may be from 84 to 88 per cent. of water, from 2·60 to 5·30 per cent. of sugars, and from 0·94 to 1·50 per cent. of nitrogenous matter.

An analysis made at the Agronomic Station of ripe and unripe pods gave the following differences per cent. in the whole pod:—

	In 100 parts of unripe pods	In 100 parts of ripe pods
Water	74·20	11·39
Ash	1·27	4·96
Cellulose	7·74	38·29
Fat	0·88	15·06
Non-nitrogenous matter ...	13·03	19·91
Nitrogenous matter ...	2·88	10·39
	100·00	100·00
Nitrogen	0·45	1·66

The husks contain a very high proportion of cellulose:—

	Per cent.
Water	11·02
Ash	4·93
Cellulose	55·55
Fat	1·07
Non-nitrogenous matter	23·96
Nitrogenous matter	3·47
	100·00
Nitrogen	0·56

These are average figures and it is on the above amounts of ash that the mineral elements have been calculated on the proportion of ash:—

	In 100 parts of pure ash	In 100 parts of husks
Silica	1·35	0·066
Chlorine	5·95	0·293
Sulphuric acid	1·48	0·073
Phosphoric acid	2·74	0·125
Lime	8·30	0·409
Magnesia	6·55	0·323
Potash	42·25	2·083
Soda	2·68	0·132
Oxide of iron	1·03	0·051
Carbonic acid, &c.	27·67	1·375
	100·00	4·930

The seeds which are not utilized serve for the plant's reproduction. Their composition is as follows:—

Water	10·40 per cent.
Ash	3·94 „
Cellulose	6·75 „
Fat	21·60 „
Sugars	4·54 „
Non-nitrogenous matter	27·59 „
Nitrogenous matter	25·18 „
	100·00
Nitrogen	4·06 „

Our researches have shown that these seeds contain a fairly large proportion of fat and a very small quantity of starch. The mineral elements are present in the proportions indicated below:—

	In 100 parts of pure ash	In 100 parts of seeds
Silica	0·42 ...	0·016
Chlorine...	Traces ...	Traces
Sulphuric acid	1·75 ...	0·069
Phosphoric acid	20·45 ...	0·806
Lime	8·48 ...	0·334
Magnesia	8·60 ...	0·339
Potash	33·96 ...	1·338
Soda	0·23 ...	0·009
Oxide of iron	0·55 ...	0·022
Carbonic acid, &c.	25·56 ...	1·007
	100·00	3·940

The composition of leaves and stems is as follows:—

	In 100 parts of dry matter	In 100 parts of natural substance
Water	— ...	83·66
Ash	9·89 ...	1·61
Cellulose	32·13 ...	5·25
Fat	4·76 ...	0·77
Non-nitrogenous matter	31·66 ...	5·19
Nitrogenous matter	21·56 ...	3·52
	100·00	100·00
Nitrogen...	3·46 ...	0·56
Nitrogen as protein	2·00 ...	0·33

The proportion of protein nitrogen to the total amount of nitrogen is 59·8 per cent.

As growth proceeds these leaves wither and fall and thus enrich the soil in which the plant is growing by returning to it the mineral elements abstracted. Considering the

wealth of foliage this plant possesses the amount returned should be fairly high :—

	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of natural substance
Silica	8·14	0·805	0·131
Chlorine	1·20	0·118	0·019
Sulphuric acid ...	5·40	0·534	0·087
Phosphoric acid ...	4·85	0·479	0·078
Lime	15·45	1·528	0·248
Magnesia	6·77	0·669	0·109
Potash	27·90	2·759	0·449
Soda	1·87	0·185	0·030
Oxide of iron ...	6·75	0·667	0·108
Carbonic acid, &c. ...	21·67	2·146	0·351
	100·00	9·890	1·610

These results show that *Dolichos bulbosus* is a most useful plant, capable of being used as a rotation crop on a large scale, and with the additional advantage of producing a relatively large amount of roots useful as fodder for cattle.

DOLICHOS FABÆFORMIS.

This is a Dolichos with angular and exceedingly vigorous stem. In certain parts of India cattle browse the stems and leaves. The pods, which attain a length of 7 cm., are eaten in the same way as haricot beans, but they must be very young. The seeds are not eaten by the Hindus.

Sagot gives the seed analysis as follows :—

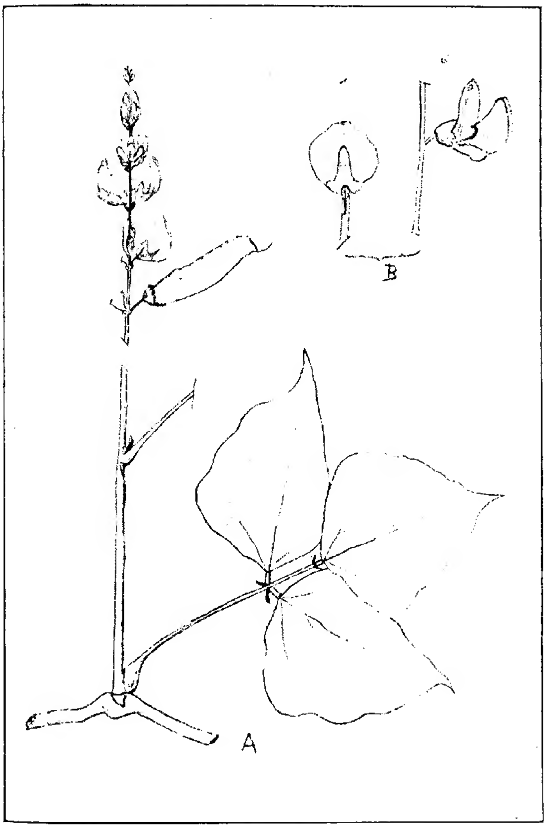
Water	10·97
Ash	3·71
Fat	1·38
Starch	55·00
Nitrogenous matter	28·94
	100·00

DOLICHOS LABLAB (BONAVIS BEAN).

Dolichos lablab is largely cultivated in Southern Asia, and especially in India, where it would appear to be indigenous.

D. lablab, the Indian name of which is " avere," is found

along all the Egyptian portion of the African coast. It was discovered in the East Indies in 1794.



[Sketch by P. A. Desmuisseaux.

FIG. 15.—*Dolichos lablab* (Bonavis Bean). A, leaf and inflorescence with young fruit; B, flower.

This is a vigorous leguminous plant which buds early. Its flowers are odorous and gathered into clusters, and

white or violet in colour. The pods are flat, curved, short and wrinkled, and generally contain three flat seeds of oval form, which differ from other peas in being capped with a white hilum. They are from 1·1 to 1·4 cm. in length; 10 grm. usually contain from fifty to fifty-five seeds.

Both dwarf and climbing varieties are found. The two dwarf races have violet and white flowers respectively, with white seeds. The latter has been collected in America in 1904, and forms low, compact tufts, similar to those of the dwarf pea, whence project long erect spikes provided with a great number of large, odorous flowers of pure white.

Those just described make excellent cover crops; they may be kept up year after year, when they yield a large and continuous supply of produce. Such is the method of their use in the North of Africa.

The climbing varieties cannot be grown through canes, as owing to the manner in which they spread they would injure the growth of the young canes. This drawback was demonstrated in a trial made at the Agronomic Station. The plants were sturdy, green, and of large size, but the canes were spoiled.

Planted every second row, they yielded, when in flower, 10,470 kilos of green forage to the hectare. The stems and leaves form an excellent fodder, their composition being as follows:—

	In 100 parts of dry matter	In 100 parts of natural substance
Water	—	81·00
Ash	8·77	1·66
Cellulose	35·32	6·71
Fat	3·15	0·60
Sugars	7·66	1·45
Non-nitrogenous matter	26·55	5·06
Nitrogenous matter	18·55	3·52
	100·00	100·00

The mineral composition of the stems and leaves shows about the same content as regards fertilizing elements as that of other peas:—

	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of natural substance
Silica	3·96	0·347	0·065
Chlorine	6·39	0·560	0·106
Sulphuric acid	3·01	0·265	0·050
Phosphoric acid	7·46	0·654	0·123
Lime	18·40	1·613	0·305
Magnesia	5·58	0·489	0·092
Potash	34·25	3·003	0·568
Soda	1·90	0·166	0·031
Oxide of iron	1·91	0·167	0·031
Carbonic acid, &c.	17·14	1·506	0·289
	100·00	8·770	1·660
Nitrogen	—	2·97	0·56

If we were to calculate from these figures the yield from a cultivation in successive rows, that is to say, from a full cultivation, we should have 20,940 kilos of green forage to the hectare.

The amount abstracted by the total harvest would thus be :—

Silica	13·60 kilos
Chlorine	22·20 ,,
Sulphuric acid	10·47 ,,
Phosphoric acid	25·75 ,,
Lime	63·87 ,,
Magnesia	19·26 ,,
Potash	118·96 ,,
Soda	6·49 ,,
Oxide of iron	6·49 ,,
Carbonic acid, &c.	60·51 ,,
Total mineral matter	347·60 kilos
Nitrogen	117·27 ,,

When the green matter is ploughed in, which is usually the case in a rotation, no loss takes place, but it is different when a seed crop is taken. In Réunion the consumption of these seeds is a large one, and there is no doubt that they are splendid eating peas.

It is unfortunate that this plant cannot be cultivated in Mauritius with any profit for the sake of its fruit, as the seeds are in great favour, but the pods always swarm with caterpillars which devour the seeds completely. Although it grows well in Mauritius it is unfortunately impossible to obtain any harvest.

We have made an analysis of seeds from Réunion and have ascertained that their nutritive value is higher than that of beans:—

Water	14·07 per cent.
Ash	3·60 ,,
Cellulose	13·15 ,,
Fat	1·25 ,,
Non-nitrogenous matter	45·06 ,,
Nitrogenous matter	22·87 ,,
	100·00

The analysis given by M. Dybowski, in his "Traité pratique de culture tropicale," agrees very closely with our own.

In India the husks are used as fodder for cattle.

D. lablab is not in regular cultivation in India, it is more often found in gardens or round about dwelling-places.

There are two varieties, one with white and the other with dusky purple flowers, which occur chiefly in the Central Provinces. As has been already noted, there are several distinct varieties in existence. In the West of India it is planted in the fields; the pods are gathered early and the peas eaten in the same way as beans. Mollison states that on good land, with good cultivation, a harvest may be obtained of 1,400 kilos of pods to the hectare, with an equal weight of forage.

The genus includes a number of varieties identifiable by the colour of the seeds: white, brown, black, &c.

D. lablab is not much used for forage, as in those countries where the fruit reaches maturity without having been destroyed by caterpillars or other insect pests it is preferred to harvest the seeds for human consumption. In Mauritius, where such harvest is *nil*, it might be used as fodder; but it is more usually ploughed in or left on the field.

A few seeds harvested at Réduit gave:—

	In 100 parts of white		In 100 parts of red
Water	13·65	...	13·90
Ash	3·65	...	4·01
Cellulose	9·02	...	8·98
Fat	1·22	...	1·03
Sugars	—	...	—
Non-nitrogenous matter	50·58	...	49·31
Nitrogenous matter	21·88	...	22·77
	100·00		100·00
Nitrogen	3·50	...	3·64
Nitrogen as proteins	3·31	...	--

It is a vigorous plant of considerable value. A great deal is made of it in India and in those countries where its employment is possible. In Cochin China the black seed variety is known as "dau ban tia," and the white as "dau ban tlang"; it is widely distributed in China, where it is called "tsu pien teu," or "pe pien teu."

According to Brunner, *D. lablab* is cultivated throughout the gardens of Brazil and Senegal. A large quantity is produced in Egypt, under the Arab name of "lablab," and the seed is commonly known in France as "dolique d'Egypte."

Dr. Leather, Indian Government Chemist, gives the composition to be as follows:—

	In 100 parts of seeds		In 100 parts of leaves and husks as gathered from the threshing floor
Water	9·59	...	9·92
Ash	4·01	...	13·87
Cellulose	6·57	...	16·17
Fat	1·25	...	3·72
Non-nitrogenous matter	57·23	...	42·95
Nitrogenous matter	21·35	...	13·37
	100·00		100·00
Nitrogen	3·69	...	2·56
Protein nitrogen	3·42	...	2·14

M. Balland gives the following weights for 100 seeds from different varieties cultivated in Madagascar:—

Brown lablab	30·3 gr.
Yellow "	23·5 "
Black "	31·2 "

	In 100 brown	In 100 yellow	In 100 black
Water	11·70	11·10	12·00
Ash	3·50	3·70	3·75
Cellulose	5·90	7·55	5·65
Fat	1·50	1·10	1·12
Non-nitrogenous matter	54·68	53·85	54·78
Nitrogenous matter ...	22·72	22·70	22·70
	100·00	100·00	100·00

Specimen seeds of *D. lablab* without their coats, forwarded by M. de Vilmorin, gave a weight of 47·90 gr. for the hundred seeds. Their proximate composition was as follows:—

Water	14·20 per cent.
Ash	3·10 ,,
Cellulose	9·15 ,,
Fat	0·96 ,,
Non-nitrogenous matter	52·78 ,,
Nitrogenous matter	19·81 ,,
	100·00

The proportion of phosphoric acid in these seeds varies with the species. M. Balland finds the figures to be as follows:—

From Tonkin	1·50 per cent.
,, Madasgascar	0·85 ,,
,, Réunion	1·15 ,,
,, Sudan	0·85 ,,

M. Advisse Desruisseaux states that in Anjouan a wild variety is found with villous stems, leaves only two-thirds the size of those of the ordinary species, and covered with hairs. The flowers are small, reddish yellow, the standard marbled with purple-red, and in erect groups.

The pod in the young state is reddish, covered with erect hairs, each ending in a gland containing a shining, sticky, yellowish-coloured fat body, which encloses two dark roundish seeds.

M. Desruisseaux considers that this legume might be used as an improving crop.

DOLICHOS SESQUIPEDALIS.

D. sesquipedalis attains a height of 3 metres, with pods from 15 to 18 cm. long. The pods are eaten in their green state before the seeds have formed and make an excellent vegetable.

The Cuban Dolichos (Cuba asparagus bean) is entirely different from the foregoing.

This species is probably a native of Africa. It is a plant of vigorous growth which thrives well in all warm countries. It bears rapidly and is highly productive. According to Sagot, after three months' cultivation it may produce more than a kilo of green pods per square metre. A few trials have been attempted in Mauritius with unsatisfactory results. Like the majority of the Phaseoleæ, it is attacked by the fly *Agromyza*.

Of much more vigorous growth than *D. sesquipedalis*, it yields pods 70 cm. long, of cylindrical shape, extremely elongated, very thin, and irregularly twisted.

DOLICHOS UNIFLORUS.

According to Baker, this species is a form of *D. biflorus*. It is a leguminous plant which may be cultivated for its seed as well as for fodder, but it is the former which is usually harvested. It is cultivated in India, where it, too, is known as "horse gram."

The composition of the seeds is as follows:—

Water	9·70	per cent.
Ash	6·32	,,
Cellulose	4·67	,,
Fat	0·96	,,
Non-nitrogenous matter	55·85	,,
Nitrogenous matter	22·50	,,
	100·00	
Nitrogen	3·60	,,
Nitrogen as proteins...	2·92	,,

say 81·5 per cent. of the total nitrogen as proteins.

These seeds, which were forwarded to M. Bonâme and

sown at Réduit, gave fairly satisfactory results. The plant is of upright growth and may be grown through canes, where, although its leaf mass is inferior to that of the cow-pea and *ambérique* (*Phaseolus helvolus*), it is still very useful in a mixed cultivation.

It yields a fodder of the following composition :—

	In 100 parts of dry matter	In 100 parts of natural substance
Water ...	—	80·50
Ash ...	7·20	1·40
Cellulose	31·18	6·08
Fat ...	4·31	0·84
Sugars ...	4·52	0·88
Non-nitrogenous matter	36·23	7·06
Nitrogenous matter	16·56	3·24
	100·00	100·00
Nitrogen	2·65	0·52

In 1,000 kilos of green fodder, the chief mineral elements are :—

Nitrogen ...	5·20 lb.
Lime ...	2·47 ,,
Potash ...	4·90 ,,
Phosphoric acid	0·83 ,,

the percentage composition of the ash being as follows :—

	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of natural substance
Silica ...	5·41	0·390	0·076
Chlorine	3·90	0·281	0·055
Sulphuric acid ...	4·36	0·314	0·061
Phosphoric acid ...	3·93	0·427	0·083
Lime ..	17·62	1·269	0·247
Magnesia	6·08	0·438	0·085
Potash ...	35·00	2·520	0·490
Soda ...	1·33	0·095	0·019
Oxide of iron ...	3·53	0·254	0·049
Carbonic acid, &c.	16·84	1·212	0·235
	100·00	7·200	1·400

This plant might also be employed as a green manure and be ploughed in when in flower, but it is inferior to the cow pea and Jack Bean, which contain a much higher proportion of organic matter.

ERVUM LENS (LENTIL).

From the remotest times the lentil has been known to serve as food for man. We know, in fact, that Esau exchanged his birthright for the seeds of this leguminous plant. Pliny, in Book XVIII, justified this exchange when he stated that the lentil imparts an equable temperament to those who eat it (*æquanimitatem fieri vescentibus ea*).

It was known to the Greeks as *facos*, and the Romans called it *lens*.

According to de Candolle, the lentil (*Ervum lens*) seems to have existed in Western temperate Asia, in Greece, and in Italy. In some prehistoric time men thought of cultivating it and carried it to Egypt. Thence, at some date less remote but still perhaps prehistoric, it spread both East and West, to Europe and the Indies. Thence, again, as trade increased, it no doubt spread to other colonies around.

It would thus seem that this leguminous plant, like so many others, came to us from India, and although the lentils of that country are largely used for food, those from Mauritius are much more highly valued, not only because of their rarity, but because of their much superior flavour.

From Cossigny, in 1802, we learn that lentils were grown in equal quantity, but were reserved for the white man's table.

The lentil is planted over very large areas in India, and these are the sources of supply for certain countries, such as Mauritius, for instance, where, owing to the fact that the lentil only thrives well in particular districts, its cultivation cannot be extended. It requires water, and localities capable of being irrigated are best adapted to it. It is not suited to damp and cold situations.

The seeds differ in colour and weight according to the variety, as can be seen from the following average weights for 100 seeds from lentils of different localities, given by M. Balland :—

France and colonies	Other countries
2·97 gr.	2·49 gr.
7·45 „	5·18 „
2·89 „	6·22 „
6·43 „	6·30 „
6·98 „	6·56 „

At the same time it should be noticed that as regards the composition of these seeds there is but little difference. The limits may be :—

	Minimum per cent.	Maximum per cent.
Water	11·00	13·50
Ash	1·75	3·15
Cellulose	2·88	3·75
Fat	0·50	1·45
Non-nitrogenous matter	56·07	62·45
Nitrogenous matter	19·36	24·64

Average weight of 100 lentils = 2·34 gr.

These analyses, which are taken from M. Balland's book, "Les Aliments," omit the proportion of sugar.

From different researches we have established a proportion of 4 to 5 per cent.

	In 100 parts of black lentils	In 100 parts of red lentils
Water	12·75	13·05
Ash	2·96	4·73
Cellulose	4·10	2·00
Fat	1·25	0·75
Sugars	5·00	4·67
Non-nitrogenous matter	51·24	51·70
Nitrogenous matter	22·70	23·10
	100·00	100·00

From the nutritive point of view there is scarcely any difference between Mauritian and Indian lentils; it is merely a question of taste.

	Mauritius In 100 parts	India In 100 parts
Water	12·24	10·80
Ash	2·56	2·54
Cellulose	6·65	7·35
Fat	0·72	0·76
Non-nitrogenous matter	53·52	55·80
Nitrogenous matter	24·31	22·75
	100·00	100·00

On stripping there are usually found 90 per cent. of seeds and 10 per cent. of husks, which, according to M. Balland, have the following composition :—

Water	10·40 per cent.
Ash	2.50 ,,
Cellulose	27·50 ,,
Fat	0·50 ,,
Non-nitrogenous matter	48·68 ,,
Nitrogenous matter	10·42 ,,
	100·00

Indian lentils do not seem to differ much in composition, and the analysis given by the *Agricultural Ledger* corresponds fairly closely to those made here.

The proportions of phosphoric acid in these seeds, when in the dry state, are :—

Lentils from Tunis	0·78 per cent.
,, New Caledonia	1·53 ,,
,, Réunion	0·80 ,,
,, Egypt	1·12 ,,

The proportion of sulphuric acid is 0·129 in lentils from Réunion, and 0·227 in Egyptian lentils.

HEDYSARUM CORONARIUM (SULLA).

According to M. Bonâme, sulla was greatly appreciated as fodder in Algeria during the drought of 1893, and it has rapidly acquired a certain reputation in that country. Arguing from this, M. Bonâme saw no reason why it should not be cultivated with success in Mauritius, but his trials have not given very satisfactory results. The sulla, after a strong and rapid development at the beginning of 1897, gradually became more and more jeopardized and finally disappeared completely. In Réunion results would appear to have been more satisfactory, and the following analysis was made of hay forwarded by M. de Villèle :—

Water	12·88 per cent.
Ash	9·40 ,,
Cellulose	23·50 ,,
Fat	0·88 ,,
Non-nitrogenous matter	42·72 ,,
Nitrogenous matter	10·62 ,,
	100·00
Protein matter	7·50 per cent.

Sulla is a vigorous forage crop and gives a large yield, provided it is cut immediately the flowers put in an appearance. It may be dried and preserved as hay. This legume thrives best in calcareous soils.

MUCUNA PRURIENS (COW-ITCH).

We shall do no more than mention this pea, which is known as cowhage or cow-itch on account of the hairs covering the pods, which work into the skin and cause irritation.

It is a plant with long, twining stems, and its leaves are split up into three large leaflets. The flowers are in long hanging clusters. The action of its hairs on the skin would seem to preclude its utilization.

M. Balland states that the seeds are eaten by negroes after cooking in water, and gives their composition to be as follows:—

Water	10·90	per cent.
Ash	3·50	,,
Cellulose	7·85	,,
Fat	3·25	,,
Non-nitrogenous matter	45·03	,,
Nitrogenous matter	29·47	,,
	100·00	

Average weight of 100 seeds = 43·86 gr.

MUCUNA UTILIS (BENGAL BEAN).

This herbaceous and trailing leguminous plant is also known as *Mucuna atropurpurea*, its common name being the Bengal bean.

It is probably a native of Arabia. We are unable to say whence this pea came to Mauritius; its existence seems to date back to the eighteenth century, as M. Desbassyns quotes it as being an excellent rotation crop.

Like all Leguminosæ, this pea is best planted at the beginning of the wet season. There are four varieties in existence: white, veined, black, and (var.) *lyoni;* the variety with black seeds being known as the *pois noir.*

From an agricultural point of view this plant gives splendid results. It is of very sturdy habit, and forms on the soil surface a regular blanket, thick and tufted, which prevents the growth of weeds. It is very easy to cultivate, all that requires doing being to sow two or three seeds together at intervals of a metre. In this way the growth of the plants is fairly well assured and the ground soon covered.

Its leaf organs are very large, it is a great spreader, covers the ground for two years at least, and produces an abundant amount of seed.

The great size of its leaf organs allows this plant to store up a large amount of nitrogen, and this, in addition to its great productivity and its content of fertilizing matter, places it in the front rank of cover peas. It will be seen further on, in a table giving the percentage proportion of nitrogenous matter to the dry matter of green fodders, that the Bengal bean contains 25 per cent. more nitrogen than the legume which is next richest in that substance.

At the same time its yield on the fields is lower than that of the cow pea, which, though less rich in nitrogenous matter, gives a higher sum of fertilizing elements, its weight to the hectare being higher.

A characteristic peculiar to the Bengal bean and the cow pea is that roots are given off at every point where the creeping stems touch the soil. This probably increases the number of nodules, and, if Hellriegel and Wilfarth's theory be correct, this peculiarity should have an appreciable influence on the enrichment of the soil in nitrogen, especially as the nodules are of large size.

This pea is distributed throughout a number of colonies, and in Mauritius it is generally to be found covering the fields in those districts where rotations are practised. The

seeds are used to feed to live stock, and the stems and leaves are ploughed in between the rows before planting.

They may also be used as fodder, a capacity in which they are very good on account of their high proportion of proteins. However, preference is usually given to ploughing in, an operation which enriches the soil, breaks it up, and renders it productive. The reason for their not being more widely used as fodder is that practice has shown them to be less useful in this respect.

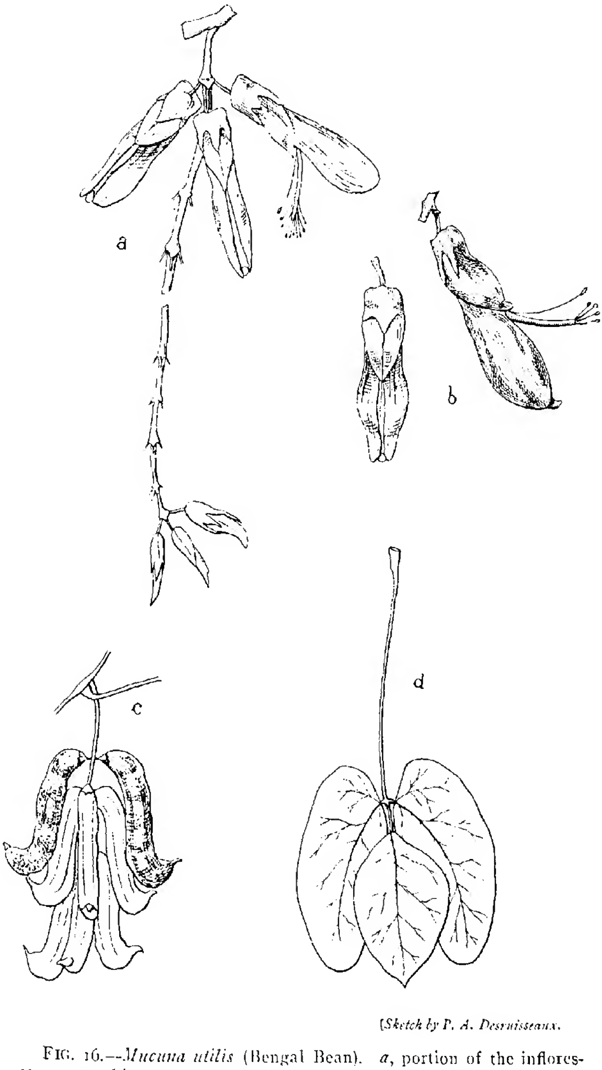
As already mentioned, the seeds of the Bengal bean are used for feeding live stock; owing to their nutritive properties being highly concentrated, they should be mixed with poorer substances, so that the animal may derive the maximum of nutriment from its allowance.

Water	11·74	per cent.
Ash	3·40	,,
Cellulose	5·76	,,
Fat	2·64	,,
Non-nitrogenous matter	50·46	,,
Nitrogenous matter	26·00	,,
	100·00	
Nitrogen	4·16	per cent.

The dry pods, which contain a 61 per cent. proportion of seeds, have husks practically incapable of being utilized, even when crushed up, as they have no nutritive value, their high content of cellulose rendering both ingestion and digestion difficult.

Their composition is as follows:—

	In the husk in 100 parts	In the seed in 100 parts	In the whole fruit in 100 parts
Water	5·23	6·10	11·33
Ash	1·50	1·87	3·37
Cellulose	12·71	3·78	16·49
Fat	0·28	1·78	2·06
Non-nitrogenous matter ...	18·10	32·68	50·78
Nitrogenous matter ...	1·18	14·79	15·97
	39·00	61·00	100·00



[Sketch by P. A. Desruisseaux.

FIG. 16.—*Mucuna utilis* (Bengal Bean). *a*, portion of the inflorescence, two-thirds natural size; *b*, flowers, natural size; *c*, small cluster, one-third natural size; *d*, leaf, quarter natural size.

The composition of each variety is as follows :—

	White	Black	Striped	Lyoni
Water	12·30	14·70	13·75	13·00
Ash	3·24	3·28	3·44	3·80
Cellulose	4·85	6·80	4·67	5·50
Fat	2·78	3·26	4·54	2·83
Sugars	4·90	2·76	5·10	3·20
Non-nitrogenous matter	48·18	46·64	46·68	46·67
Nitrogenous matter ...	23·75	22·56	21·82	25·00
	100·00	100·00	100·00	100·00
Nitrogen	3·80	3·60	3·49	4·00
Average weight of 100 seeds	85·5 gr.	74·2 gr.	81·5 gr.	85·7 gr.

Before they are mature the pods and seeds give the following figures :

	In 100 parts of unripe pods	In 100 parts of unripe seeds
Water	83·20	58·70
Ash	0·86	1·45
Cellulose	3·87	3·63
Fat	0·06	1·24
Non-nitrogenous matter	11·04	25·30
Nitrogenous matter	0·97	9·68
	100·00	100·00
Nitrogen	0·15	1·55

The following yields per hectare were obtained in Hawaii, where this pea is under cultivation :—

A cultivation sown in May and harvested in December gave 8·3 tons of seed and 40·3 tons of green fodder.

Another variety yielded 14·2 tons of seed per hectare and 28·4 tons of green fodder. These are the figures given by the agricultural scientist, M. Krauss.

The amount of green fodder obtained from our trials was 46·7 tons. As we have already stated, it is but little used as fodder; the plants are generally left to fruit and the seeds given to the cattle. At the same time we have analysed its composition :—

	In 100 parts of dry matter	In 100 parts of natural substance
Water	— ...	82·18
Ash	8·10 ...	1·44
Cellulose	28·41 ...	5·06
Fat	5·30 ...	0·94
Sugars	3·26 ...	0·58
Non-nitrogenous matter	27·93 ...	4·99
Nitrogenous matter	27·00 ...	4·81
	100·00	100·00
Nitrogen	4·32 ...	0·77

[*Photo by G. Rehaut.*

FIG. 17.—*Mucuna utilis* (Bengal Bean). Pods and seeds of black, white and striped varieties.

This fodder in Hawaii has about the same proximate composition, but it is somewhat less rich in protein, and its potash and phosphoric acid content is higher.

Hawaii	Fertilizing elements in 1,000 lbs
Nitrogen	5·5
Phosphoric acid	1·4
Potash	5·7

Mauritius	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of natural substance
Silica	3·50	0·280	0·050
Chlorine	3·42	0·275	0·049
Sulphuric acid ...	3·31	0·266	0·047
Phosphoric acid ...	7·00	0·561	0·100
Lime	16·95	1·361	0·242
Magnesia	6·45	0·517	0·092
Potash	32·00	2·567	0·456
Soda	1·52	0·122	0·022
Oxide of iron ...	3·54	0·283	0·051
Carbonic acid, &c. ...	22·31	1·868	0·331
	100·00	8·100	1·440

Taking an average proportion of 46,670 kilos of green fodder to the hectare, the totals of mineral substances come to :—

	Kilos
Silica	23·34
Chlorine	22·86
Sulphuric acid	22·74
Phosphoric acid	46·67
Lime	112·94
Magnesia	42·93
Potash	212·83
Soda	10·26
Oxide of iron	23·38
Carbonic acid, &c.	154·14
Total mineral matter	672·09
Nitrogen	35·94

All these elements are returned to the soil when the crop is ploughed in. Only the mineral matter in the seeds used as food are withdrawn, but this loss is balanced by their value as food.

The average yield of green fodder quoted above is for a crop taken during florescence.

We see that in Hawaii the yield in green matter, after the crop has fruited and the pods have been gathered, averages 33 tons.

In conclusion, it is interesting to note the use to which the Bengal bean is turned in Montserrat (West Indies). It

was utilized at first for the sake of the mass of organic matter provided, but it was subsequently observed that sickly limes about which the Bengal bean was grown regained their vigour. This use of the plant has been extended, and it is stated that excellent results have been obtained. Four or five seeds are sown round the plant, which picks up quicker the more thickly it is covered. Immediately the stems are dry the limes regain their vitality.

The reasons for this action are not properly known, but it is supposed that the humidity retained by the peas favours the development of certain fungi which destroy their insect enemies.

PISUM SATIVUM (GREEN PEA).

The green pea, whose culture was advocated by Charlemagne, who called it *Pisum mauriscum*, has been cultivated from the remotest times. Dioscorides, Pliny, and Galenus speak of its cultivation and the utilization of its seeds.

The garden pea or green pea, *Pisum sativum*, is a native of Western Asia, where it apparently existed without being cultivated. The Aryan peoples no doubt introduced it into Europe, but M. Balland believes that it probably existed in Southern India before the arrival of the Eastern Aryans.

It was cultivated by the Greeks in the time of Theophrastus, and has been discovered in the lake dwellings of Switzerland.

It is now cultivated in every part of the globe, and in one direction and another numerous varieties have been formed. These manifold varieties fall into two chief categories, distinguishable by the nature of their pods. In some the pods are coated with a hard and coriaceous membrane; these are called parchment peas, or peas with hard pods. Others, on the contrary, have pods devoid of such membrane.

The composition of green peas is as follows:—

Water	84·10 per cent.
Ash	0·55 ,,
Cellulose	1·32 ,,
Fat	0·28 ,,
Sugars	2·00 ,,
Non-nitrogenous matter	8·24 ,,
Nitrogenous matter	3·51 ,,
	100·00

In the dry state they have about the same nutritive value as beans :—

Water	12·80 per cent.
Ash	2·28 ,,
Cellulose	5·20 ,,
Fat	1·40 ,,
Non-nitrogenous matter	57·76 ,,
Nitrogenous matter	20·56 ,,
	100·00

The green pods yield about 50 per cent. of seeds, whilst the proportion of seeds per cent. of dry pods varies between 90 and 92.

Their weights vary according to the varieties, and the average weight of 100 peas, according to M. Balland, is 15·1 gr. for Indian; 20·8 gr., 21·9 gr., 33·4 gr., 19 gr. for New Caledonian; and 16·3 gr. for those from Réunion.

Their composition shows little variation, and the limits observed for the above peas are 20·5 to 23 per cent. of nitrogenous matter, 0·85 to 1·35 per cent. of fat, 2 to 3·7 per cent. of ash, and 2·5 to 4·85 per cent. of cellulose.

On the average the following figures are obtained :—

	Minimum per cent.	Maximum per cent.
Water	9·80 ...	14·20
Ash	2·00 ...	3·70
Cellulose	2·38 ...	5·52
Fat	0·85 ...	1·65
Non-nitrogenous matter	56·18 ...	61·10
Nitrogenous matter	18·11 ...	26·68
Average weight of 100 peas ...	15·1 gr. ...	50 gr.

The dry husks contain 48 per cent. of cellulose.

Water	12·20 per cent.
Ash	2·50 ,,
Cellulose	48·50 ,,
Fat	1·20 ,,
Non-nitrogenous matter	29·00 ,,
Nitrogenous matter	6·60 ,,
	100·00

Peas, like beans, keep for a very long while, and retain their germinative capacity for a fairly long period. At the end of the first year peas placed in water absorb 100 per cent. of the liquid.

In 1856, Poggiale stated at the Académie des Sciences that partially formed peas contain more nitrogen than those harvested when perfectly ripe.

M. Balland gives the proportion of phosphoric acid contained in the green pea. In its normal state—that is to say, with 82 per cent. of water—the proportion of phosphoric acid is 0·27, whilst in the dry state it is 1·52 per cent.

In the green husks containing 82·3 per cent. water, the proportion of the above element is 0·12 per cent., and in the dry state 0·68 per cent.

The amount of sulphur reckoned as sulphuric acid is 0·23 per cent.

Every horticulturist or gardener knows how to sow the green pea. It is planted towards the end of the winter, and care should be taken to choose the variety best suited to the particular locality where it is to be grown.

In Mauritius a few trials made through canes succeeded fairly well. Dwarf varieties are sown for this purpose.

Numerous varieties of green pea have been introduced into all tropical countries. As has already been mentioned, different species grow and fruit better in different localities.

PHASEOLUS ACONITIFOLIUS.

Phaseolus aconitifolius is a bean grown in India. It is a small species, which grows even in bad soils. Two varieties are cultivated, a white and a black. It forms one of the "dholls," and is used a great deal in the feeding of native horses, oxen, goats, and sheep. The Hindus mix them with certain dishes.

We append an analysis made by Sagot :—

Nitrogen	11·22	per cent.
Ash	3·56	,,
Fat	0·64	,,
Non-nitrogenous matter	60·78	,,
Nitrogenous matter	23·80	,,
	100·00	

Dr. Leather gives an analysis :—

Water	9·94	per cent.
Ash	4·02	,,
Cellulose	4·60	,,
Fat	0·86	,,
Non-nitrogenous matter	58·21	,,
Nitrogenous matter	22·37	,,
	100·00	
Nitrogen	3·58	per cent.
Nitrogen as proteins	3·20	,,

LATHYRUS SATIVUS (EVERLASTING PEA, SPANISH LENTIL, GESSE).

Lathyrus sativus (commonly called everlasting pea, or Spanish lentil) is also cultivated in India, where it occupies an area of 2,000 to 2,500 hectares.

The ground should be prepared, and the seeds sown at the rate of from 80 to 95 lb. to the hectare. The crop is harvested five to six months later, before the fruit is completely ripe.

Mollison states that on an average the weight of pods may vary from 2,190 to 2,530 lb. to the hectare, and the weight of forage from 2,890 to 3,325 lb. to the same area.

This plant is chiefly cultivated as a forage crop; but it thrives well, and its seeds are used on a large scale by the lower classes as food, chiefly in the form of bread.

Its poisonous properties are dealt with in the chapter on dangerous plants.

The following is the analysis from the *Agricultural Ledger* :—

	Seeds	Leaves and husks from threshing floor
Water	7·89 per cent.	8·59 per cent.
Ash	4·37 ,,	13·77 ,,
Cellulose	4·28 ,,	19·97 ,,
Fat	0·79 ,,	3·96 ,,
Non-nitrogenous matter	56·36 ,,	42·40 ,,
Nitrogenous matter ...	26·31 ,,	11·31 ,,
	100·00	100·00
Nitrogen	4·21 per cent.	1·81 per cent.
Nitrogen as proteins ...	3·95 ,,	1·44 ,,

PHASEOLUS CARACALLA.

The following is a reprint from notes by M. Denaiffe in his book on beans :- -

This species is a native of warm countries, where, in its wild state, it grows in the form of lianes, forming an almost impassable barrier.

It has a perennial tuberculate root, giving rise to a woody, branched, and climbing stem, which may attain a height of more than 3 metres; the leaflets are small, rhomboid, oval, tapering to a longish point. The petioles of the inflorescences are longer than the leaves, and bear as many as twenty flowers; but the majority are sterile, and only a limited number of pods are developed.

The flowers are large, very fragrant, white in colour, with a wash of lilac, and have the standard, wings, and keel spirally twisted; husks straight, torose, pendent, with numerous atrophied seeds; the latter are small, lenticular, and dark-brown in colour; their length and width is 0·007 metre, and their thickness varies from 0·002 to 0·003 metre.

According to some writers (G. Van Martens), the statement that this plant is a native of the East Indies is erroneous, as A. de Candolle shows that there is no name for this bean in Sanscrit; on the other hand, Polhet and Martins have found it growing wild in Brazil; further, its name *Caracolleiro* is Portuguese; it is called in Spanish *Caracollillo*, and in Italian *Caraguol*. From these names, which all have the same root, is derived (whether as the result of a wrong

impression or of a misunderstanding) the unsuitable nomenclature of *Caracalla*.

The seeds, of which this bean bears but a small quantity, are useless for food; on the other hand, with their superb flowers blooming in turn from the beginning of July till October, they are splendid plants for adorning arbours or covering walls. At the same time these flowers only come to their full beauty in very hot climates or in well-warmed greenhouses.

Von Martens relates having seen this plant growing out of doors in the botanical garden at Pavia, but states that under these conditions the florescence lacked most of its brilliance, the flowers being smaller in size and of a brownish tint; in addition, petioles, leaflets, and flowers as well showed a tendency to fall to pieces, leaving a bare stem.

It is a hothouse plant, which may, if necessary, be cultivated in the Midi and Provence if against a wall of warm and sheltered aspect.

PHASEOLUS HELVOLUS (AMBÉRIQUE).

Phaseolus helvolus, which has been known in Réunion for several centuries, has never been described by botanists. Jacob de Cordemoy makes no mention of it. A pea called *Phaseolus helvolus*, of similar aspect and vegetation to the plant under consideration, has been known to exist in Louisiana. It would be interesting to make a comparison between these two varieties with a view to establishing their positions.

In 1908, M. Blouin received from Réunion from M. de Villèle a number of seeds of *Phaseolus helvolus* which might be compared with those of Louisiana, but M. Blouin was unable to give a definite decision, and the doubt still remains.

Phaseolus helvolus is a native of Madagascar, though the date of its introduction to Réunion is not known. In the statement made by the Marquis Henri du Quesne in 1689 to

all those Protestants who wished to help him to found a Republic in the Ile d'Eden (Bourbon), we find the following passage: "There are beans like those of Brazil which bear for seven years without resowing; they are as good as the large beans of Europe. There are others—smaller—called 'antaques'; they, too, live for seven years. There are others, white, yellow, and red in colour; the haricot beans thrive there as in Europe; yet another sort possesses pods a foot long, the flavour of the seeds being similar to that of the above; the shells may be eaten when green. There are those of still another kind called 'ambérique,' in whose pods are small green and yellow seeds, which are extremely good."

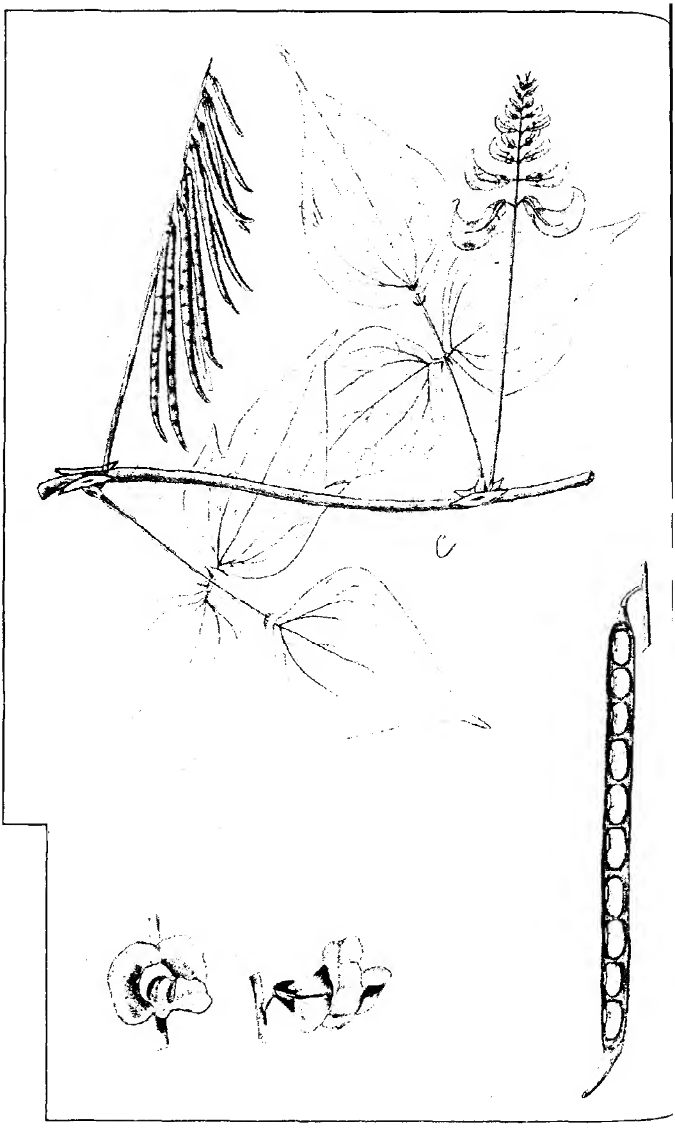
Clear proof is thus forthcoming that at this period "antaques" and "ambériques" were cultivated in Réunion. As regards the beans with pods a foot long, everything points to it being the cow pea which was meant. There are a number of varieties, but the commonest are the yellow and black.

There is considerable similarity of composition between *Phaseolus helvolus* and the Indian cow pea; the latter, called *Phaseolus Mungo*, contains more nitrogenous elements than *helvolus*.

It is a leguminous plant with smaller leaf development than the "ambérique," and covers the soil fairly rapidly, but it is rather exacting in its early stages as regards cultivation; that is to say, it is affected by the proximity of weeds at this period. Its seed has a very pronounced "wild" taste, and it is used chiefly as food by the lower classes.

Harvesting is carried out by threshing the stems which have been cut down to the soil level and accumulated on a portion of the field cleaned previously. All other seeds, such as beans, peas, &c., are picked by hand. It is interesting to note that at those spots where after a certain time the runners have decomposed, the plants which are cultivated or grow wild flourish better than elsewhere.

In Mauritius, M. Bonâme has been conspicuous in testing and advocating its cultivation.



[Sketch by P. A. Desruisseaux.

FIG. 18. Ambérique (*Phaseolus helvolus*) from Réunion. *a*, flowers; *b*, open pod and seed; *c*, branch.

When planted between the rows at the Agronomic Station it developed remarkably well without damaging the canes in any way. Results have been obtained from several varieties, but the yellow has given most satisfaction.

The green variety is very early, but remains short; its seeds mature before those of any of the cow peas. Its slender stalks bear less foliage, and its yield on the fields, both in seeds and forage, is considerably less.

The yellow variety is a plant which is particularly well adapted to a mixed cultivation. Its stems are nearly straight and spread very little horizontally, and it can grow without disturbing the young canes at all. It is sown under similar conditions to the cow pea, but more closely if the ground is to be covered rapidly. The cylindrical pods are, on the average, only 7·5 cm. long by 4 to 5 mm. broad. The seeds are generally eight in number; 100 grm. contain 2,855, 100 seeds weighing 3 to 4 grm.

Appended are the results of trials made at the Agronomic Station and published in the Annual Report for 1910:—

YELLOW VARIETY.

	In 100 parts of green forage	In 100 parts of dry matter
Water ...	79·50	—
Ash ...	1·90	9·20
Cellulose	8·83	43·06
Fat ...	0·98	4·81
Sugars	1·58	7·70
Non-nitrogenous matter	4·60	22·48
Nitrogenous matter	2·61	12·75
	100·00	100·00
Nitrogen	0·42	2·04

On comparing the mineral matter of ambériques with those of cow peas the proportion of the different elements is scarcely seen to differ at all, but when correlated to the crop per hectare a much lower total of mineral matters is found, the returns to the soil being much less by weight relative to the green crop.

	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of natural substance
Silica	5·40	0·497	0·103
Chlorine	3·95	0·363	0·075
Sulphuric acid ...	3·34	0·307	0·063
Phosphoric acid ...	5·77	0·531	0·110
Lime	20·61	1·896	0·392
Magnesia	9·40	0·865	0·179
Potash	24·52	2·256	0·466
Soda	0·21	0·019	0·004
Oxide of iron ...	2·87	0·264	0·055
Carbonic acid, &c. ...	23·93	2·202	0·453
	100·00	9·200	1·900

The composition of the total crop is as follows:—

Silica ...	4·637 kilos
Chlorine	3·376 ,,
Sulphuric acid ...	2·836 ,,
Phosphoric acid...	4·952 ,,
Lime ...	17·640 ,,
Magnesia	8.058 ,,
Potash ...	20·977 ,,
Soda ...	0·180 ,,
Oxide of iron ...	2·476 ,,
Carbonic acid, &c.	20·392 ,,
Total mineral matter	85·530 ,,
Nitrogen	18·91 ,,
Weight of the green crop...	4.500 ,,
,, ,, dry ,, ...	922·8 ,,

After harvesting the seeds there remains on the fields 3,008 kilos of green crop and 675 kilos of dry, giving 8·72 kilos of nitrogen and 58·974 kilos total mineral matters.

Silica ...	4·423 kilos
Chlorine	3·279 ,,
Sulphuric acid ...	2·016 ,,
Phosphoric acid	1·535 ,,
Lime ...	15·857 ,,
Magnesia	6·049 ,,
Potash	10·379 ,,
Soda ...	0·391 ,,
Oxide of iron ...	1·692 ,,
Carbonic acid, &c.	13·353 ,,
	58·974 ,,

We have had occasion to analyse the composition of green varieties which differ somewhat from the yellow as regards potash. The green seems to require a large quantity of this element; both thrive equally well in the same soils.

As is the case with all Leguminosæ, a loose soil is best suited to it, but save in too firm a soil *Phaseolus helvolus* will thrive with equal ease anywhere.

Green forage	In 100 parts of dry matter	In 100 parts of natural substance
Water ...	—	85·00
Ash ...	11·59	1·73
Cellulose	29·84	4·47
Fat ...	3·50	0·52
Sugars ...	6·13	0·92
Non-nitrogenous matter	29·51	4·45
Nitrogenous matter	19·43	2·91
	100·00	100·00
Nitrogen	3·11	0·46

The proportion of protein nitrogen being 2·30, the percentage of assimilable nitrogenous elements is 73·9.

	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of natural substance
Silica	4·00	0·463	0·069
Chlorine	5·88	0·681	0·102
Sulphuric acid	3·70	0·429	0·064
Phosphoric acid	4·50	0·521	0·077
Lime	17·30	2·005	0·300
Magnesia	6·58	0·762	0·113
Potash	35·08	4·065	0·606
Soda	3·38	0·392	0·058
Oxide of iron	2·12	0·246	0·036
Carbonic acid, &c.	17·46	2·026	0·305
	100·00	11·590	1·730

The nutritive value of the seeds in the two varieties is not identical. The green is richer in nitrogenous matter. Generally speaking, the consumption is limited, as after cooking this seed has a dusty and unappetizing flavour, and is only used by the lower classes.

Appended is a table showing the proximate composition of these two seeds compared :—

	Yellow (per cent.)	Green (per cent.)
Water ...	12·68	11·63
Ash ...	3·34	3·27
Cellulose	5·90	5·05
Fat ...	1·50	0·75
Sugars ...	6·90	7·80
Non-nitrogenous matter	52·62	47·75
Nitrogenous matter	17·06	23·75
	100·00	100·00
Nitrogen	2·73	3·8

The same difference is encountered in the figures given by M. Bonâme in his report for 1910.

The nutritive ratio is 1 : 3·6 and 1 : 2·4, and the nutritive value 75 and 80 per cent.

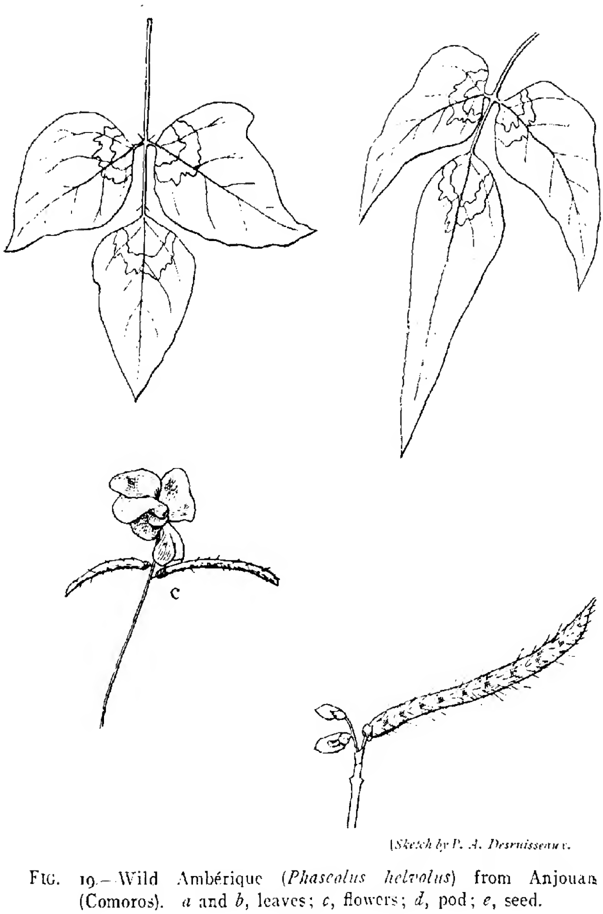
An extremely large proportion of potash and phosphoric acid is found in the seeds, while most of the magnesia is in the husks.

The sale of the seeds or their local consumption compensates for the elements abstracted, and, like all other leguminous plants, "ambérique" may be turned in green when in flower or left for seed, stems and leaves remaining on the fields.

	In 100 parts of pure ash	In 100 parts of seed
Silica	0·16	0·006
Chlorine	2·27	0·082
Sulphuric acid	5·07	0·183
Phosphoric acid	28·45	1·024
Lime	4·98	0·179
Magnesia	8·35	0·301
Potash	42·80	1·540
Soda	4·34	0·118
Oxide of iron	0·48	0·117
Carbonic acid, &c.	3·10	0·150
	100·00	3·600

The husks are scarcely ever used, and their debris remain on the land. They might, however, be utilized as an absorbent for certain nutriments, such as molasses. We append their composition, which rather points to their being a coarse food.

	In 100 parts of dried husks
Water	10·76 per cent.
Ash	5·00 ,,
Cellulose	37·10 ,,
Fat	0·76 ,,
Non-nitrogenous matter	39·26 ,,
Nitrogenous matter	7·12 ,,
	100.00
Nitrogen	1·14 per cent.



[*Sketch by P. A. Desruisseaux.*

FIG. 19.—Wild Ambérique (*Phaseolus helvolus*) from Anjouan (Comoros). *a* and *b*, leaves; *c*, flowers; *d*, pod; *e*, seed.

MINERAL COMPOSITION OF THE HUSKS.

	In 100 parts of pure ash	In 100 parts of husks
Silica	1·75	0·087
Chlorine	1·05	0·053
Sulphuric acid	0·54	0·027
Phosphoric acid	3·54	0·177
Lime	21·07	1·053
Magnesia	16·18	0·809
Potash	26·35	1·318
Soda	2·04	0·102
Oxide of iron	1·42	0·071
Carbonic acid, &c.	26·06	1·303
	100·00	5·000

According to notes sent by our colleague Desruisseaux, a wild variety of *Phaseolus helvolus* is found in Anjouan (Comoro Islands) with flowers similar to those of the Réunion species. The leaves are smaller, dark green in colour, with a partially circular light-coloured stain occupying the lower third portion, the edges undulate; stems villous, creeping, and climbing; the pod is hairy and measures from 6 to 7 cm.; the hairs are upright, and the pod turns blackish when ripe. It contains from eight to twelve almost rectangular chestnut-coloured seeds, with darker dots and a whitish hilum.

M. Desruisseaux thinks this variety might serve as a cover crop.

Thanks to M. Desruisseaux, who has kindly forwarded us samples from the Comoros, we have been enabled to study the composition of this plant.

We have obtained about the same results as for those grown in Mauritius.

STEMS AND LEAVES.

	In 100 parts of dry matter	In 100 parts of natural substance
Water	—	86·30
Ash	12·08	1·65
Nitrogen	3·04	0·41

Its mineral composition is practically the same :—

	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of natural substance
Sulphuric acid	1·36	0·164	0·022
Phosphoric acid	5·94	0·717	0·098
Lime	17·92	2·165	0·295
Magnesia	5·54	0·669	0·091
Potash	35·58	4·298	0·587
Soda	0·74	0·089	0·012
Oxide of iron	3·82	0·461	0·063

PHASEOLUS MUNGO (WOOLLY PYROLUS).

The Woolly Pyrolus was unknown to the Greeks and Romans, for it appears to have been imported from India by Arabs, who introduced it into Egypt and Southern Europe.

The fact that these peas are mentioned in a book published at Anvers in 1567, entitled "Plantes et Racines," from the pen of a Portuguese doctor, seems to show that their cultivation in Spain and Portugal has been practised for ages past.

Martens relates having seen them in a corn merchant's shop in Venice, where they were called *Fasioletti del India;* as a matter of fact, they certainly did not come from India, but from Genoa, and had been grown and obtained in that district. This represents M. Denaiffe's opinion, from whose book, "Les Haricots," we have borrowed the above lines.

Phaseolus mungo is a species of bean which requires a warm climate for its successful development, and is in all probability a native of India. It is an erect plant, from 50 cm. to 1 metre in height. The leaves resemble those of the common bean, and are hairy and wrinkled. The yellowish-green flowers arise in pairs at the extremity of the common peduncle which springs from the leaf axil and rises above it. The pods, from 6 to 8 cm. long, are straight, cylindrical, and terminate in a short point. They contain from ten to fifteen seeds 5 mm. long and 4 mm. thick.

There are a number of varieties in existence, and analyses of several are published by Professor Church in the *Bulletin of the Department of Agriculture of Sydney* (*Australia*).

	Green variety	Yellow variety	Variegated variety
Water	10·8	11·4	10·1
Ash...	4·4	3·8	4·4
Cellulose	5·8	4·2	4·8
Fat	2·7	2·0	2·2
Non-nitrogenous matter	54·1	54·8	55·8
Nitrogenous matter ...	22·2	23·8	22·7
	100·0	100·0	100·0

The nutritive value of these beans is 83 per cent.

M. Balland shows that 100 seeds of the Indian *Phaseolus mungo* weigh 2·65 gr., and 100 seeds of the Cambodian variety weigh 4·90 gr.

The following figures are taken from M. Balland's work: -

	Indian per cent.	Cambodian per cent.
Water	10·20 ...	12·00
Ash	3·50 ...	3·55
Cellulose	5·85 ...	3·10
Fat	1·15 ...	1·25
Non-nitrogenous matter	57·19 ...	56·82
Nitrogenous matter	22·11 ...	23·28
	100·00	100·00

In the normal state this bean contains 1·01 per cent. of phosphoric acid.

In many districts in Australia it is held in high esteem and considered to be a healthy food. We may note that the ashes of the stems and leaves are sometimes used as a substitute for salt in the cooking of food dishes; at Dinajpur, for instance.

According to Sir Walter Elliot, *Phaseolus mungo* is one of the most valued leguminous plants in India. Sixty-two pods, each containing seven to fourteen seeds, have been gathered from one plant. Pailleux relates, on the authority of Baron von Mueller, that the young shoots form a delicate dish.

Like all other Leguminosæ, this bean is sown at the commencement of the wet season. The seeds are dibbled in at intervals of 45 cm., or they may be broadcasted, but the first method is preferable.

It grows well in practically all soils, provided they are not too firm. Whatever the nature of the soil cultivated, it is advisable to prepare it to a certain extent in order to facilitate the growth of the root system, enabling it to penetrate into the subsoil and to protect the plant from drought.

Generally speaking, this legume is not eaten by cattle, and it is not grown for fodder.

The Woolly Pyrolus has a wide distribution in India, and is eaten by all classes of the inhabitants.

Appended is a list of analyses made by the Chemist to the Indian Government, Dr. W. Leather, and published in the *Agricultural Ledger*:—

	P. MUNGO		P. MUNGO, VAR. RADIATUS	
	Average of six samples	Leaves and husks from threshing floor	Average of five samples	Leaves and husks from threshing floor
Water	9·97	15·38	10·38	13·30
Ash	4·57	14·92	4·12	14·29
Cellulose ...	3·81	17·08	3·80	18·66
Fat	0·93	1·70	1·07	2·52
Non-nitrogenous matter ...	58·29	38·24	56·76	39·67
Nitrogenous matter	22·43	12·68	23·87	11·56
	100·00	100·00	100·00	100·00
Nitrogen ...	3·59	2·03	3·82	1·85
Nitrogen as proteins	3·33	1·79	3·40	1·74

In Anjouan (Comoro Islands) the native, in order to grow this bean, simply burns off the scrub, and after sowing it takes no more notice of it till harvest time, two and a half months later. It is often cultivated in weeded soil along with other crops. We owe these notes to the kindness of our colleague, Desruisseaux, agricultural engineer in the Comoros.

In Australia, as in India, the harvest takes place two and a half to three months after sowing. The pods are left to dry thoroughly in the sun, and the seeds are then easily separated from the husks.

After the seeds have been gathered the residue may be used for straw or be ploughed in; or still another method is to burn it on the land and allow the ash to enrich the soil.

This bean is not adapted to cold climates and must be acclimatized. It withstands drought well.

PHASEOLUS INAMŒNUS (POIS DU CAP).

The origin of the Pois du Cap (*Phaseolus inamœnus*) is uncertain, though Bojer thinks it is a native of the Cape of Good Hope.

Cossigny believes that they have spread from Cap Français. They cannot have come from the Cape of Good Hope, as the Dutch took Réunion and Mauritius before 1802. There is more ground for believing that these peas are really natives of Madagascar, where large quantities are harvested at Cape Tuléar.

It seemed to be thought that old plants produced bitter fruit, and Cossigny adds that all the Leguminosæ are dangerous as soon as they are bitter. Besides, the fact that cases of poisoning were recorded at this period seems to point to poisonous properties being attributed to certain Leguminosæ. The Pois du Cap (a large bean in Mauritius) is the fruit of a perennial leguminous plant thriving in practically all soils, but unable to adapt itself to all climates. The vigorous stems reach a height of 4 metres and bear a large amount of foliage; the pods are from 0·08 to 0·10 metres long and 0·024 to 0·026 metres broad, flat, and curved like a sickle.

The seeds are from 0·020 to 0·023 metres long, 0·013 to 0·014 metres wide, and 0·007 metres thick.

This variety is particularly recognizable by the curious speckling of its seed, which shows a large red stain extending from around the umbilicus over the smaller portion of the pea, whilst the other portion is dotted with the same colour on a white background.

It must not be thought, however, that this is the sole variety. We have seen some in Bourbon and the Comoro Islands which were of a totally different appearance. Some were completely white with a reddish-brown spot at the

umbilicus, while others had the red stain both at the umbilicus and over the whole of the portion opposite.

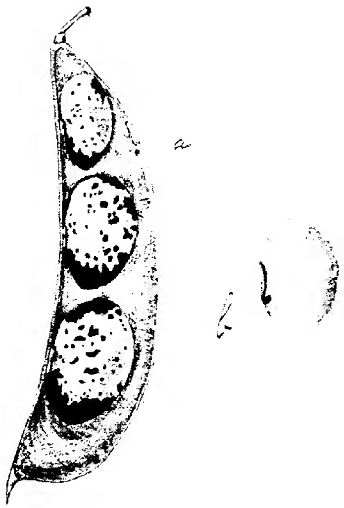
[Photo by Desruisseaux.

FIG. 20. A plant of Pois du Cap which has climbed about a banana tree in Anjouan.

The seeds vary in size according to the varieties. Some are only 13 to 15 mm. broad.

Wet and damp climates are not at all suited to this bean; it requires a warm climate, and will show a remarkable development in hot localities which are not too moist.

In Mauritius it does not grow very easily, and does not attain more than a moderate size. It is cultivated a great deal in Madagascar, and forms the major portion of the dry



[Sketch by P. A. Desruisseaux.

FIG. 21.—*a*, fruits of Pois du Cap (*Phaseolus inamœnus*); *b*, white variety.

legumes exported. The following are the export figures for beans gathered around Tuléar:—

Year		Weight in tons		Value
1901	...	710	...	£7,918
1902	...	1,684	...	14,990
1903	...	1,144	...	11,271
1904	...	930	...	9,928
1905	...	1,441	...	19,110

It is largely grown and used in Réunion.

Its composition is as follows :—

Water	16·01 per cent.
Ash	3·60 ,,
Cellulose...	4·70 ,,
Fat	1·42 ,,
Sugars	6·20 ,,
Non-nitrogenous matter	50·07 ,,
Nitrogenous matter	18·00 ,,
	100·00

This Pois du Cap is usually known only as a food seed. It shows, however, as a forage and rotation crop, considerable similarity with *Phaseolus lunatus*. It covers the soil well, spreads widely, and gives a highly compact mass of vegetation.

The quality of the fodder for an equal amount of dry matter differs little from that of the Bengal bean. The following analysis, published by M. Bonâme in 1897, was made from stems in full growth, with their tissues turgid with water.

	In 100 parts of leaves	In 100 parts of seeds
Water	84·76	13·92
Ash	1·48	5·16
Cellulose	4·10	3·75
Fat	0·61	1·00
Non-nitrogenous matter	5·86	57·24
Nitrogenous matter	3·19	18·93
	100·00	100·00

This legume is a very suitable one for growing as a pure crop, and would yield a fairly large amount of vegetable matter which, when ploughed in, would mean a high proportion of organic matter incorporated with the soil.

PHASEOLUS LUNATUS (LIMA BEAN).

Phaseolus lunatus was discovered in 1779, and is classed by de Candolle as a native of Bengal. Known as the d'Achery pea, it is also called Burmah pea, "pois amer," &c.

The latter appellation would appear to be the best, as it naturally conveys its unsuitability as a food. When planters

in Mauritius gave it the name of the d'Achery pea they were ignorant of the fact that in Bourbon there was an edible pea of the same variety called d'Achery, but of a totally different colour, the bitter pea being reddish purple, whilst the d'Achery pea is white. It is certain that not a few varieties exist which have been modified and improved by cultivation, and it is impossible to classify them as good or bad according to their colour; generally speaking, however, those which are reddish purple in colour or show veining on a red ground are doubtful.

Cossigny, who was the first, in his "Traité d'amélioration des Colonies," to treat of our Leguminosæ, has been the unwitting cause of this confusion. When he spoke of the d'Achery pea he certainly meant the one which is cultivated and eaten in Bourbon, which was introduced into Mauritius by a member of the d'Achery family, settlers who still inhabit Réunion.

The same writer, in the treatise mentioned above, makes no mention of its origin, nor of the date when d'Achery introduced it; but he does not speak of the peas having poisonous properties, which tends to show that the peas known at Mauritius as d'Achery peas are not identical with those introduced by this settler. As a matter of fact, they are absolutely distinct from those known and eaten in Réunion.

Peas called "Pois de Chine" (China peas) were formerly found in Mauritius, which, in Bourbon, were known as "Pois d'Achery rouges." According to Cossigny, the latter were thought to be considerably inferior to the white. These plants, like those of the present day, were perennial, lived for several years, and spread considerably.

The d'Achery pea is described by M. Jacob de Cordemoy ("Flora of Réunion") as follows: "The tuberous root is perennial. In the wild state this bean bears dark violet-coloured seeds, almost polyhedrous in shape, and exceedingly poisonous; it is then called 'Pois amer' (bitter pea). Under the influence of cultivation the form and colour of

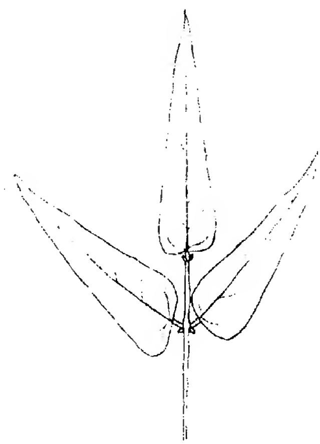
the seeds are modified. They become more compressed, yellowish, marked with violet streaks and stains, and are then only rarely poisonous. This form is commonly known as 'Pois d'Achery.' A more prolonged cultivation under the best conditions leads to a new variation. The seeds, increasing in size, become still further flattened, and their colour approaches more and more to the pure white. They are then called 'Pois doux, 'Pois d'Adam' sweet pea, Adam pea), and being now harmless may be eaten without any fear; moreover, they have an agreeable flavour. This plant is a native of Bengal. Cultivated for a considerable time past in Réunion, where it was greatly valued as a restorative crop for soils sown with canes, it has been replaced by other Leguminosæ on account of the frequent cases of poisoning for which it has been responsible. Even to-day it is sometimes the cause of mishaps. The chemist Marcadieu, who was formerly employed to analyse these seeds, writes of having found prussic acid present."

Phaseolus lunatus is a very popular rotation legume. It is perennial and resows itself naturally by means of the seeds falling on the soil, which remains covered for several years (seven-year pea) with a thick layer of verdure. When sown at the commencement of the rains it soon covers the ground with a luxuriant vegetation. This vegetation is only continuous in localities where drought is not too prolonged. Along the littoral, where the vegetation only recovers with the advent of the first rains, its appearance is sporadic.

The Lima bean is a most valuable plant for restoring soil fertility. Throughout the whole of its period of growth it sheds numerous leaves which decay and enrich the soil, so that when, after the soil has been occupied by this crop for one or more years, this sum of organic matters is ploughed under, a good manuring is effected. The subsequent crops are always superior when the soil has been prepared in this way.

The Lima bean is very largely employed as a cover

crop, for, up to the present, it and *Mucuna utilis* had been, one may say, the only plants used for this purpose; however, after experiments with *Vigna Catjang* preference must be given to this latter. The same result is obtained in a much shorter space of time, and the land does not remain unproductive. We shall see later what comparisons can be made between these two Leguminosæ.



Sketch by P. A. Desrwissanve.

FIG. 22.—Leaf from a variety of *Phaseolus lunatus*. Quarter natural size. Anjouan (Comoros).

In 1898-99 M. Bonâme investigated the composition of the seeds and leaves of the Lima bean. They have a value equal to that of other Leguminosæ, but must still be regarded with suspicion owing to the presence of prussic acid, which occurs in every portion of the plant.

	Ripe seeds	Leaves and stems
Water ...	11·70	78·00
Ash ...	3·70	1·68
Cellulose	6·25	4·80
Fat ...	0·94	0·55
Non-nitrogenous matter ...	53·29	10·81
Nitrogenous matter	24·12	4·16
	100·00	100·00
Nitrogen	3·86	0·66

The percentage composition of the ash demonstrates the presence of high proportions of potash and phosphoric acid in the seeds, and of potash and lime in the stems and leaves, the proportions of magnesia remaining almost the same in both cases.

	In 100 parts of ash		In 100 parts of green matter		In 100 parts of dry matter	
	Seeds	Leaves	Seeds	Leaves	Seeds	Leaves
Silica ...	2·27	10·00	0·084	0·168	0·095	0·762
Chlorine	4·34	3·70	0·161	0·062	0·182	0·282
Sulphuric acid ...	1·28	1·58	0·047	0·026	0·053	0·120
Phosphoric acid	24·36	6·19	0·901	0·104	1·023	0·472
Lime ...	2·47	23·30	0·091	0·392	0·104	1·775
Magnesia	7·58	6·80	0·281	0·114	0·318	0·518
Potash	49·36	27·68	1·826	0·465	2·073	2·109
Soda ...	2·92	1·90	0·108	0·032	0·123	0·145
Oxide of iron ...	0·74	3·03	0·027	0·051	0·031	0·236
Carbonic acid, &c.	4·68	15·82	0·174	0·266	0·198	1·201
	100·00	100·00	3·700	1·680	4·200	7·620
Nitrogen	—	—	3·86	0·66	4·37	3·03

The whole pod contains :—

	In 100 parts of full pods		
	Husks	Seeds	Whole pods
Water ...	4·30	8·38	12·68
Ash ...	1·10	2·20	3·30
Cellulose	14·91	3·25	18·16
Fat ...	0·29	1·23	1·52
Non-nitrogenous matter	15·47	36·25	51·72
Nitrogenous matter	0·93	11·69	12·62
	37·00	63·00	100·00
Nitrogen	0·144	1·87	2·014

We will waste no time in investigating the nutritive value of this pea, as, rightly or wrongly, it is scarcely ever used in view of the mishaps recorded.

We have examined the mineral composition of the husks, which is always interesting knowledge, and, further, informs

us as to the abstraction of mineral elements from the soil. These elements are returned to the soil by ploughing under the stems and leaves remaining on the fields, whilst the pods are gathered merely for reproductive purposes.

	In 100 parts of ash	In 100 parts of dry matter	In 100 parts of husks
Silica ...	6·80	0·227	0·201
Chlorine ...	0·61	0·020	0·018
Sulphuric acid ...	1·55	0·052	0·045
Phosphoric acid ...	6·24	0·208	0·184
Lime ...	16·65	0·556	0·492
Magnesia...	7·41	0·247	0·219
Potash ...	32·37	1·081	0·958
Soda ...	2·46	0·082	0·073
Oxide of iron ...	4·44	0·148	0·131
Carbonic acid, &c....	21·47	0·719	0·639
	100·00	3·340	2·960

Other samples from our experimental fields have been analysed with the following results:—

STEMS AND LEAVES.

	In 100 parts of dry matter	In 100 parts of green matter
Water ...	—	78·80
Ash ...	7·50	1·59
Cellulose ...	44·07	9·34
Fat ...	2·57	0·54
Sugars...	3·60	0·76
Non-nitrogenous matter ...	30·50	6·48
Nitrogenous matter ...	11·76	2·49
	100·00	100·00
Nitrogen ...	1·88	0·40

Generally speaking, the pods have a proportion of 63 per cent. of seeds and 37 per cent. of husks; a full pod weighs on an average 3 grm., and a seed 0·390 grm.

The husks form a coarse and rather poor food, their composition being as follows:—

	In 100 parts of green matter	In 100 parts of dry matter
Water ...	11·62	—
Ash ...	2·96	3·34
Cellulose ...	40·30	45·59
Fat ...	0·78	0·88
Non-nitrogenous matter ...	41·84	47·44
Nitrogenous matter ...	2·50	2·75
	100·00	100·00
Nitrogen ...	0·39	0·44

Taken as fodder the stems and leaves of the Lima bean have a nutritive value as high as that of the other Leguminosæ, and it is unfortunate that they should be totally barred as a food for stock.

The mineral analysis gives, near enough, the same figures as those previously quoted from M. Bonâme's trials.

	In 100 parts of ash	In 100 parts of dry matter	In 100 parts of natural substance
Silica ...	4·95	0·371	0·078
Chlorine ...	3·95	0·296	0·063
Sulphuric acid	3·52	0·264	0·056
Phosphoric acid	6·52	0·489	0·103
Lime ...	21·38	1·603	0·340
Magnesia ...	10·25	0·778	0·163
Potash ...	27·98	2·098	0·445
Soda ...	0·85	0·063	0·013
Oxide of iron	3·10	0·232	0·049
Carbonic acid, &c. ...	17·50	1·306	0·280
	100·00	7·500	1·590

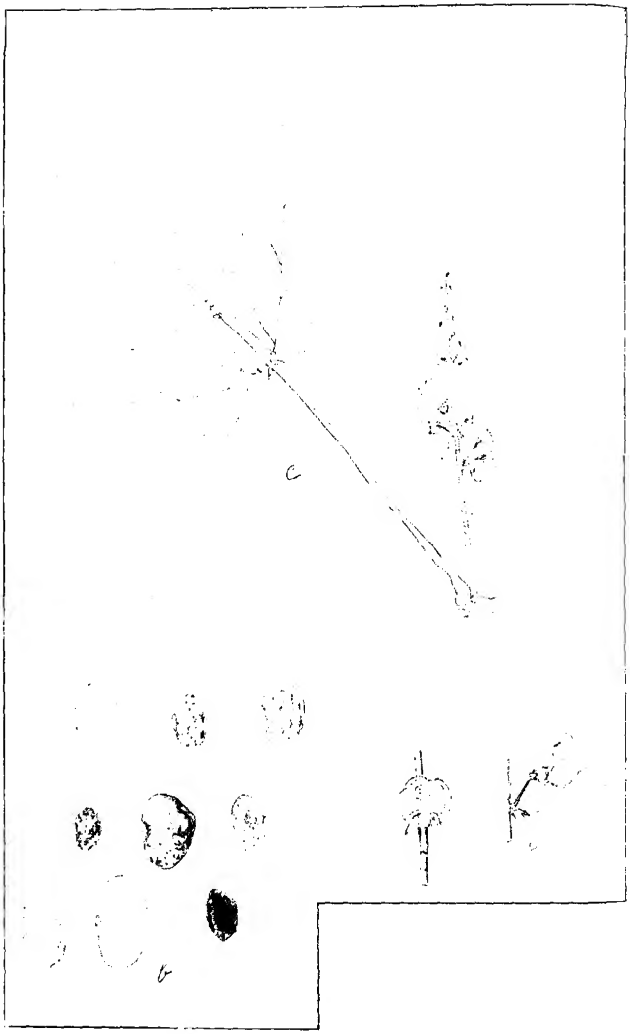
The Lima bean is a legume to be grown as a pure crop; it is not adapted to cultivation as an inter-crop with canes, its stems spreading too far and its growth being too tufted. The crop is sown at the beginning of the wet season; the seeds should be sown in groups 0·66 metres apart, with two or three seeds in each group. The three plants should be left in order that the ground may be covered more rapidly.

The plant needs no further attention once it is strong enough to resist the weeds; consequently, care should be taken to keep the plantation clean.

If the plant is only to stand for one year the peas are ploughed in at florescence, *i.e.*, when their development and assimilation have reached their maximum.

The sum of organic matters may be considerable, and depends on the conditions of climate and growth. With the yield of green matter varying from 10 to 15 tons to the arpent, the amount of organic matters will be from 2 to 3 tons for the same area.

When, as in some cases, the crop stands for two or three



Sketch by P. A. Desruisseaux.]

FIG. 23. -*Phaseolus lunatus* (Lima Bean). *a*, flower, natural size; *b*, seeds of several varieties, natural size; *c*, leaf and inflorescence, half natural size.

years, these organic matters accumulate on the ground every year and form humus; conditions then being especially favourable, the subsequent crops are more productive.

PHASEOLUS SEMIERECTUS.

In the "Report on Agricultural Work" from 1896 to 1902 for British Guiana, we see that attention is paid to this legume which is of common occurrence in that country in abandoned fields and in pastures, so long as it has not been obliterated by other plants. An inspection of its roots has shown that it possesses nodules in a much higher proportion than any other variety of cow peas. On account of its vegetation, and more especially owing to the woody nature of its stems, it is not very well adapted to ploughing under, whereas the cow pea is particularly useful in this respect.

Its composition shows it to be a highly nutritive plant, and it is a favourite with cattle. It is used in preference to other plants for feeding milch cows. In plantations, where it grows practically wild without special cultivation, it has been shown to give two crops a year with a yield of 64 tons of green forage to the hectare.

The following figures have been obtained from analyses of seeds and of the green plant:—

	Plant per cent.	Seeds per cent.
Water ...	78·78	9·92
Fat ...	0·52	2·00
Albuminoids (*a*)	1·18	16·85
Amides (*b*)	1·25	5·08
Saccharose	—	10·96
Glucose	0·36	2·94
Gums, &c.	3·01	0·70
Starch ...	—	17·43
Digestible cellulose	7·77	19·44
Wood ...	6·27	11·32
Ash ...	0·86	3·36
	100·00	100·00
(*a*) Containing nitrogen ...	0·189	2·70
(*b*) Containing nitrogen ...	0·200	0·81
	0·389	3·51

PHASEOLUS VULGARIS (COMMON KIDNEY BEAN, FRENCH BEAN, HARICOT BEAN).

This bean (*Phaseolus vulgaris*) is a plant which for a long time was thought to be a native of India, but to which we now, following de Candolle, attribute an American origin.

The word *Phaseolus* comes from *Phaselus*, the name assigned by Virgil to several legumes, which is derived in its turn from the Greek *Phaselos*, a barque, an allusion to the shape of the pods.

In the *Journal de Botanique* for 1897, M. Ed. Bonnet tells us no seed of the bean has ever been found among the lake dwellings or in Egyptian excavations, or among the ruins of Greek and Roman cities; further, this plant is neither mentioned in the Bible nor in the Talmud; we must go back to the Greek authors of the post-Homeric period in order to find, under the name of *Dolichos Phaseolos*, mention of a member of the Leguminosæ whose identity with our runner bean it has been endeavoured to establish. But the texts which the majority of authors have used to describe this species indicate other Leguminosæ.

The bean appears to have been imported into Spain and Flanders from America. Apparently it was only imported into England towards the year 1594.

The kidney bean (*Phaseolus vulgaris*) is cultivated extensively in every country of the world. Manifold varieties are in existence, and their number is increased every year.

Beans are annual plants; they may be sown throughout the year in any locality which is free from the fly *Agromyza Phaseoli*. They are divided into dwarf beans and runner beans according to their mode of growth.

The flowers are gathered in clusters of two to eight, borne on a more or less lengthy peduncle springing from the axil of a leaf. These flowers are white, pink, lilac, more or less pale, rarely violet or rose carmine.

The fruit is a pod which is composed of seeds and husk.

It is pendent, varies in shape and length, and encloses several seeds separated by the projection of cellular parenchyma. According to the variety the husks remain green or turn yellow on ripening, with the exception of those with violet husks; the seeds, like the husks, vary considerably in colour, shape, and dimensions, and it is these different characters which determine the races.

With few exceptions nearly all beans thrive well in warm countries, but there are several well acclimatized varieties which give particularly good results.

A number have been tried in Mauritius, the best acclimatized being apparently the red bean of Rodrigues Island and the black bean from France.

As to when it was introduced into Mauritius no information is forthcoming. Cossigny tells us of beans which were cultivated in the Eastern colonies. We may surmise that this plant was introduced into India from America at some fairly remote period, reaching us as soon as intercourse with these countries became more frequent.

The Rodrigues bean is a dwarf variety which may be grown the whole year round. At the same time there are chances of its failure during several months of the year, in consequence of the attacks of the fly *Agromyza*.

The best season for sowing is March-April, but in districts where the fly occurs it is October to November, at the beginning of the rains. Failing a cyclone, the bean will develop strongly and the yield will be more or less prolific according to the conditions of cultivation. A good manuring will be useful and will ensure a good crop.

The Rodrigues bean is usually grown to be picked ripe, or eaten without the husk, whilst the black, which is a trailing variety, yields pods that may be eaten green.

This dwarf variety would be particularly well suited to cultivation as an inter-crop with canes. It might be sown in three rows, and the seed crop could be taken three and a half to four months later.

When the bean is husked while full of water it gives a proportion of 50 to 60 per cent. of seeds; whereas, once they are dry the husks are only in a proportion of 8 to 9 per cent.

M. Balland, in "Les Aliments," confirms these figures, and gives the average of seeds in the completely dry pods to be 91 to 92 per cent.

Their weights vary between fairly wide limits according to the variety.

AVERAGE WEIGHT OF 100 SEEDS

France grammes		French colonies grammes		Foreign countries grammes
23·8	...	11·8	...	20·0
30·5	...	19·2	...	27·0
41·0	...	25·3	...	36·7
51·5	...	37·6	...	44·1
61·0	...	43·9	...	48·8
78·0	...	52·0	...	—
82·0	...	62·5	...	—
98·7	...	76·4	...	—
126·8	...	86·9	...	—
134·6	...	134·0	...	—

The following are the limits of composition that may occur between numerous varieties of beans:—

	Minimum per cent.		Maximum per cent.
Water ...	8·50	...	20·40
Ash ...	2·20	...	5·65
Cellulose	1·95	...	6·00
Fat ...	0·48	...	2·46
Non-nitrogenous matter ...	52·04	...	63·23
Nitrogenous matter	13·80	...	26·46

The average is:—

Water ...	13·00 per cent.
Ash ...	3·50 ,,
Cellulose...	2·85 ,,
Fat ...	1·52 ,,
Non-nitrogenous matter ...	59·15 ,,
Nitrogenous matter ...	19·98 ,,
	100·00

The bean in the green state contains:—

Water ...	92·00 per cent.
Ash ...	0·82 ,,
Cellulose ...	0·74 ,,
Fat ...	0·28 ,,
Non-nitrogenous matter ...	4·17 ,,
Nitrogenous matter ...	1·99 ,,
	100·00

These analyses are taken from M. Balland's work.

The embryos are very rich in nitrogenous matter, the proportion being as high as 44·5 per cent.

The composition of the husks is very variable, and gives limits of 4·1 to 17·8 per cent. for nitrogenous matter; similarly, the differences as regards cellulose are sufficiently large in the different varieties.

	Per cent.	Per cent.	Per cent.
Water	12·00	9·90	10·20
Ash	7·70	5·00	3·30
Cellulose	11·50	59·20	39·50
Fat	1·45	1·40	0·25
Non-nitrogenous matter	49·55	18·67	42·65
Nitrogenous matter	17·80	5·83	4·10
	100·00	100·00	100·00

The composition of the seeds is as follows:—

Water	14·80	per cent.
Ash	3·50	,,
Cellulose	2·50	,,
Fat	1·60	,,
Non-nitrogenous matter	33·10	,,
Nitrogenous matter	44·50	,,
	100·00	

All beans, from whatever country, have a nearly identical nutritive value. They are a most valuable food, eaten in the form of meal or of dry seeds.

The proportions of phosphorus and sulphur contained in these seeds differ according to the variety; we express them in phosphoric and sulphuric acid.

	Phosphoric acid per cent.	Sulphuric acid per cent.
Madagascar	0·81	—
Mayotte	1·36	0·550
New Caledonia	1·47	0·333
Réunion	1·16	—
Sudan	0·88	—
Burmah	1·07	—

These are for peas in the dry state.

After numerous experiments, M. Balland concludes that phosphoric acid in beans may amount to 1·35 per cent. in the normal state and 1·65 per cent. in the dry state, and sulphuric acid to 0·55 per cent., as in beans from Mayotte.

In Mauritius and Réunion the bean, together with the cow pea, ambérique, &c., are attacked by a small fly (*Agromyza phaseoli*), which is the cause of this crop only being grown at certain periods of the year.

This insect has been known in Réunion for a very long while, as is shown by a note of Joseph Hubert's, dated March 12th, 1800, and published by M. Bonâme in his annual report for 1906-07 :—

"I fear the insects, and I am going to begin observing them, for a number of observations have already proved to me that what is attributed here to phenomena of growth, to the varying success of different plants in winter or in summer, in localities dry or wet, in the highlands or lowlands, is in reality the work of insects. In December, the month, as regards temperature, furthest removed from July, when beans are usually planted, I have seen magnificent beans which, more often than not, perish after flowering. Very well, if such is the case, observe the stalk of the plant; you will find it full of cracks, and looking closer you will further see some grubs, small chrysalids whence emerge small black flies. Taking the stem of a bean before the flies had flown away, I saw eleven at once."

The above note was transmitted to M. Bonâme by my friend, M. A. de Villèle.

This little black fly lays its eggs upon the epidermis of the plant as soon as the bean shows two leaves; the larva detaches the epidermis in which it lives and makes descending galleries. When the number of larvæ harboured by the plant is not a large one it protects itself by means of nodular galls, which enable it to withstand the insect's attack; but the yield is diminished notwithstanding.

The existence of this insect has been recorded in Australia towards 1898, and it has had to be contended with in that country. Its habits vary in the different countries of its occurrence, and even in different districts in the same country. In Mauritius, where it is found throughout, its occurrence is

particularly local, and during a few months of the year it partially disappears. This is the only period when it is permissible to sow Leguminosæ, *i.e.*, in the month of October. At the same time, we have had occasion to notice that its attacks are less prolonged in certain years. For instance, in August, 1909, we sowed some beans which did remarkably well.

Although, at Réduit, the most favourable months for the cultivation of the bean are October to November, the period differs in other localities, not even being the same in Réunion.

Numerous remedies have been attempted : sprinkling with soot, tobacco extract, and aqueous petroleum emulsions. Not one of these means has either been a preventive or a cure.

The only remedy, by no means an efficacious one, but which tends to check the spreading of these diptera, is that of pulling up the plants attacked and of burning them as they shrivel and turn yellow.

PHASEOLUS DERASUS.

A bean which is a native of Brazil, commonly sold in the state of husked seeds in the vegetable markets of Rio de Janeiro.

Flowers of a greenish white, small, and disposed in pedunculate clusters springing from the axils of the leaves. Seeds black with a white hilum.

PHASEOLUS MULTIFLORUS.

This is a climbing plant of South American origin; it is from 3 to 5 metres high and slightly pubescent. The flowers occur in long clusters of fifteen to thirty, united in pairs, and blooming consecutively. They are white, red, or of two colours according to the variety. The pods number from

three to five in each cluster; they are green, oblong, from 18 to 20 cm. long, wrinkled, and show warty lines arranged like the fibres in parchment.

PHASEOLUS SPHÆRICUS SULFUREUS.

Phaseolus sphæricus var. *sulfureus* is a yellow bean from China. It has a wide distribution, and is held in considerable esteem. It is recorded and described in the oldest treatises, such as that of Martens. It is easily identified by the fine sulphur yellow or straw colour of its seeds, which are ovoid or almost spherical in shape.

M. Denaiffe gives the following description: A tufted, fairly ramose plant, scarcely exceeding 0·45 metres in height, foliage moderate, pure green, leaflets almost as broad as long. Husks green, acquiring a yellow tint at maturity; contain five to six seeds, sulphur yellow in colour, with a more or less distinctly marked bluish ring around the umbilicus; these pods are slightly flattened, and either straight or slightly curved.

PHASEOLUS TRILOBUS.

Plant with somewhat slender stems; flowers insignificant, yellowish, the standard and wings more or less twisted; pods cylindrical, enclosing seeds greenish-yellow in colour veined with black.

This bean is largely cultivated in India; the seed is very small, for 100 of them only weigh 1·46 grm.

The composition is as follows:—

Water	11·20	per cent.
Ash	6·50	,,
Cellulose	7·75	,,
Fat	0·59	,,
Non-nitrogenous matter	49·44	,,
Nitrogenous matter	24·52	,,
	100·00	

PSOPHOCARPUS TETRAGONOLOBUS (POIS CARRÉ).

This legume, which on account of its quadrangular pods is commonly known as the "Pois carré," is a twining herb, cultivated in gardens and rarely semi-wild. Several varieties are found, among others one with ivory white flowers and another with bluish flowers, with the posterior portion of the standard cream.

According to Sagot, this legume is a native of Southern Asia; but Mr. Burkill, "Reporter on Economic Products," of Calcutta, believes *Psophocarpus* to be a native of Madagascar.

In a special letter addressed to us in March, 1911, Mr. Burkill wrote as follows:—

"In spite of what Sagot thinks, I do not believe *Psophocarpus tetragonolobus* to be an Indian plant. Its native country would probably be Madagascar, and it is possible that a tuberculate variety has been found in the Malay Archipelago; but India has certainly received the Pois carré from elsewhere."

Attempts have been made to prove from Graham's catalogue that the Pois carré is a native of Mauritius. This is a mistake, for Burkill, commenting on Graham's phrase, "a native of Mauritius," says: "It is impossible to be sure whether Graham knew with any certainty that this plant came from Mauritius."

Burkill, who believes that our species comes from Madagascar and the one with tubercles from the Malay Archipelago, adds, in his pamphlet on "Goa Beans": "Anyone may hold the opinion that the *Psophocarpus* came to Mauritius or to Rodrigues from the Malay Archipelago, or to the Malay Archipelago from Mauritius or from Rodrigues. One point alone is clear, and that is that *Psophocarpus palustris* is more than probably of African origin, and if this latter is a native of Africa or of

Madagascar, it is fairly likely that the species *tetragonolobus*, which closely resembles it, is of the same origin."

The fact is that the point is far from being settled. What is certain is that the species *palustris* grows wild in the Comoros and Madagascar.

The variety grown in Mauritius has no tubercles: these are simply swellings of the roots where starch is stored up and which increase in size as the plant grows older. They form reserves on which the plant draws the following year, during its early growth. These reserves disappear, and the plant gives off other roots which nourish it and which act as new reserves when growth is finished.

In a trial we made on plants after two years' growth we obtained the following results:—

Roots taken from four plants gave the following weights:—

1	...	...	...	717 gr.
2	...	...	...	592 ,,
3	...	...	...	580 ,,
4	...	...	...	785 ,,

These roots, after the adherent earth had been removed by washing, yielded a proportion of 30·8 per cent. of outer layers ("skins") $1\frac{1}{2}$ to 2 mm. thick.

In the decorticated root a content of 15·8 per cent. of starch was found, which in terms of the whole root does not amount to more than 10·9 per cent.

The proximate composition of the decorticated roots was as follows:—

	In 100 parts of dry matter	In 100 parts of roots
Water	—	75·40
Ash	3·56	0·87
Cellulose	5·95	1·56
Fat	2·38	0·58
Sugars	23·38	5·75
Non-nitrogenous matter	53·29	13·03
Nitrogenous matter	11·44	2·81
	100·00	100·00
Nitrogen	1·84	0·45

These roots have a fairly agreeable flavour when boiled, and might be used as food if they could be thoroughly

[Photo by G. Rehaut.

FIG. 24.—Leaves and fruits of Pois carré (*Psophocarpus tetragonolobus*).

cooked. Unfortunately, they never can be, and their relative toughness renders them inferior.

In his pamphlet on "Goa Beans," Mr. Burkill gives an analysis of tubercles gathered and dried :–

Water	9·05	per cent.
Fat	0·98	,,
Albuminoids	24·62	,,
Carbohydrates	56·07	,,
Cellulose	5·38	,,
Ash	3·90	,,
	100·00	

The carbohydrates are chiefly starch and sugar.

We are unable to give any further particulars about these tubercles, which are derived from a special variety and consumed in India.

Seeds received from Calcutta and sown at Réduit gave plants of fine growth. We have noticed swellings which, in the variety with ivory white flowers, were of similar form to those of the variety with blue flowers.

The mineral composition of the roots resembles that of the seed, with the difference that the proportion of magnesia is higher in the root, whilst the phosphoric acid content is greater in the seed.

	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of decorticated roots
Silica	1·04	0·037	0·009
Chlorine	1·98	0·070	0·017
Sulphuric acid ...	4·32	0·154	0·037
Phosphoric acid ...	18·91	0·673	0·164
Lime	9·12	0·325	0·079
Magnesia	19·15	0·682	0·166
Potash	32·15	1·144	0·280
Soda	1·16	0·041	0·010
Oxide of iron ...	1·48	0·052	0·013
Carbonic acid, &c. ...	10·69	0·382	0·095
	100·00	3·560	0·870

The cortical parenchyma is richer in nitrogen, and the proportions of magnesia and phosphoric acid are smaller.

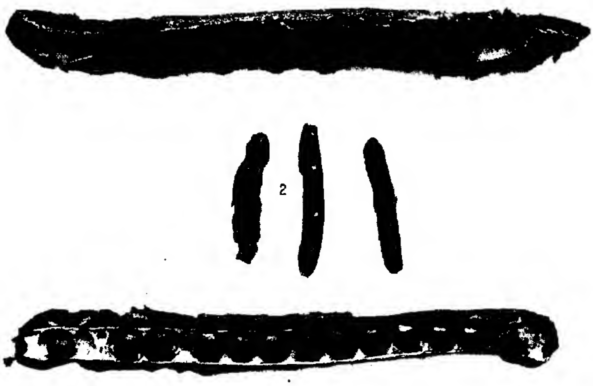
	In 100 parts of dry matter	In 100 parts of natural substance
Water	—	81·50
Ash	8·94	1·65
Nitrogen	3·55	0·66

Photo by G. Rikaut.

FIG. 25.—Roots of Pois Carré (*Psophocarpus tetragonolobus*).
Age : 2 years.

The mineral content is as follows:—

	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of natural substance
Silica	4·94 ...	0·442 ...	0·081
Chlorine	7·21 ...	0·644 ...	0·119
Sulphuric acid ...	7·21 ...	0·644 ...	0·119
Phosphoric acid ...	13·83 ...	1·236 ...	0·228
Lime	11·65 ...	1·041 ...	0·192
Magnesia	5·56 ...	0·497 ...	0·092
Potash	34·71 ..	3·103 ...	0·573
Soda	0·67 ...	0·060 ...	0·011
Oxide of iron ...	7·80 ...	0·697 ...	0·128
Carbonic acid, &c. ...	6·42 ...	0·576 ...	0·107
	100·00	8·940	1·650



[Photo by G. Rehaut.

FIG. 26.—1, dry pods of *Psophocarpus tetragonolobus* (Pois carré); 2, dry pods of *P. palustris*.

In terms of the whole root these figures are:—

	Roots 60 per cent.	Outer layers of roots 31 per cent.	Total
Silica	0·006 ...	0·025 ...	0·031
Chlorine	0·011 ...	0·037 ...	0·048
Sulphuric acid ...	0·025 ...	0·037 ...	0·062
Phosphoric acid ...	0·113 ...	0·071 ...	0·184
Lime	0·054 ...	0·059 ...	0·113
Magnesia	0·114 ...	0·028 ...	0·142
Potash	0·193 ...	0·177 ...	0·370
Soda	0·007 ...	0·004 ...	0·011
Oxide of iron ...	0·009 ...	0·039 ...	0·048
Carbonic acid, &c. ...	0·068 ..	0·033 ...	0·101
	0·600	0·510	1·110

The Pois carré, like all Leguminosæ, is sown at the beginning of the rains. It requires props for its best development, and gives pods of more or less fine quality according to the conditions of growth. These pods, quadrangular and winged, when cooked and eaten before maturity make a delicate dish relished by all.

They should be eaten when their development is half completed, and may be used in place of peas with advantage. They are usually picked when measuring 12 to 15 cm. Their composition is appended:—

	In 100 parts of dry matter	In 100 parts of unripe pods
Water	— ...	92·20
Ash	6·27 ...	0·49
Cellulose	21·78 ...	1·70
Fat	4·25 ...	0·33
Sugars	19·81 ...	1·55
Non-nitrogenous matter	21·52 ...	1·67
Nitrogenous matter	26·37 ...	2·06
	100·00	100·00
Nitrogen	4·22 ...	0·33

The husked seeds are also edible. Once dry they cook with difficulty. The dry pods contain 50 per cent. of seeds very rich in nitrogenous substances, which are almost entirely digestible; protein nitrogen representing 96·4 per cent. of the total nitrogen.

	In 100 parts of seed	In 100 parts of pods
Water	14·90 ...	14·10
Ash	3·50 ...	5·98
Cellulose	9·40 ...	39·15
Fat	15·15 ...	0·50
Sugars	7·80 ...	0·65
Non-nitrogenous matter	19·50 ...	33·12
Nitrogenous matter	29·75 ...	6·50
	100·00	100·00

In another trial made at the Agronomic Station the proportion of seeds per cent. of full pods was the same; analyses were made of the ash of both seeds and pods.

	In 100 parts of seed	In 100 parts of husks
Water	13·40	11·50
Ash	4·02	5·90
Cellulose	12·05	33·40
Fat	14·64	1·00
Sugars	8·04	—
Non-nitrogenous matter	16·21	41·58
Nitrogenous matter	31·64	6·62
	100·00	100·00
Nitrogen	5·06	1·06

In the seeds the mineral elements are found in the following proportions:—

	In 100 parts of pure ash	In 100 parts of seed
Silica	0·25	0·010
Chlorine	0·88	0·035
Sulphuric acid	1·20	0·048
Phosphoric acid	29·15	1·171
Lime	11·12	0·447
Magnesia	11·70	0·470
Potash	33·20	1·335
Soda	1·08	0·041
Oxide of iron	0·60	0·024
Carbonic acid, &c.	10·82	0·439
	100·00	4·020

In the husks, as we have already had occasion to remark, the potash content is very high, whilst the other elements are considerably less in amount.

	In 100 parts of pure ash	In 100 parts of husks
Silica	2·08	0·123
Chlorine	3·70	0·218
Sulphuric acid	5·41	0·319
Phosphoric acid	5·71	0·336
Lime	4·83	0·285
Magnesia	5·35	0·315
Potash	46·23	2·727
Soda	0·91	0·053
Oxide of iron	4·00	0·236
Carbonic acid, &c.	21·78	1·288
	100·00	5·900

Although this legume does not admit of being profitably employed in a large cultivation it may be sown in gardens, and will there be of considerable value owing to its bearing when winter vegetables are out of season.

It reproduces fairly easily, but requires a certain amount of attention during the first months of growth; manuring, weeding, hoeing, &c. After fruiting the plant dies, but remains, so to speak, perennial through its root, which, as we have already noted, stores up a reserve which allows the plant to resume growth the following year at the recurrence of the rains.

In Anjouan, and the Comoros generally, *Psophocarpus palustris* grows in the wild state associated with *Mucuna pruriens*, a wild vetch and a wild ambérique. We owe these particulars to our colleague, M. Desruisseaux, who further informs us that the young inflorescences are sometimes eaten as salad.

Seeds from the Comoros sown by M. Bonâme at Réduit have produced plants whose stems trail considerably, and whose roots soon establish themselves in the soil. They form a very thick covering, and do not lose their leaves in summer like the ordinary Pois carré; they thus offer the advantage of perennial plants, living for several years.

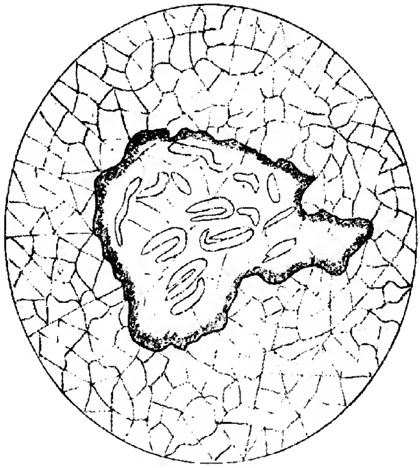
This species yields black seeds half the size of those of the Pois carré, and pods 4 to 5 cm. long, containing on the average three seeds.

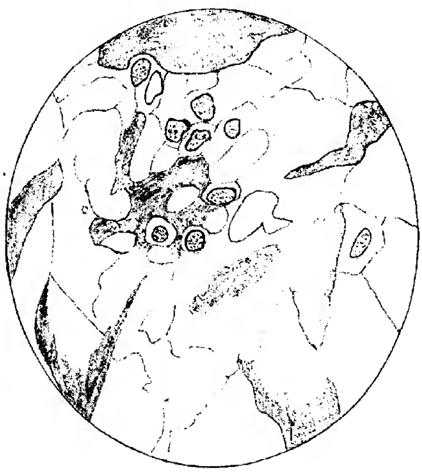
This legume might be used as a rotation crop, the only point being that it would require acclimatizing in those localities where it was to be used. As the plant thrives well nearly everywhere this would not be difficult.

We have had occasion to notice in Mauritius that the roots of *Psophocarpus tetragonolobus* were sometimes attacked by a Nematode worm, *Heterodera radicicola*. After an examination of sections which we sent him Professor Maublanc confirmed our statement. He wrote as follows: "The excrescences on the roots of the Pois carré are due to *Heterodera radicicola;* your preparations, I may say, are very good and clear. I see the tissues are strongly hypertrophied, with cavities (several of which are empty) formed by the bodies of females swollen with eggs. In one of the

[Photo by G. Rehaut.

FIG. 27.—Excrescences on the roots of the Pois carré (*Psophocarpus tetragonolobus*) due to *Heterodera radicicola*.





[*Sketches by P. de Sornay.*

FIG. 28.—Sections of excrescences on the roots of Pois carré caused by *Heterodera radicicola*. 1, eel-worms situated in the midst of hypertrophied tissue; 2, hypertrophied tissue with cavities and eggs.

preparations, which is unstained, there is one of these cavities where the eggs have commenced their development: instead of being homogeneous they enclose young larvæ ready to hatch."

In practice, the attack of these eel-worms does not seem to affect the plant in the least. They resist very well, and the vegetation remains as fine as ever.

SOJA, OR SOY BEAN.

An ancient dictionary known as *Kouang-ia* describes the soy bean under the name of *ta-teou*, or large pea, or, again as *sou*. It is supposed that the word soja is a derivative of this latter, which dates from the Han epoch.

According to de Candolle, this plant is a native of the district comprised between Cochin China, the south of Japan, and Java.

It has been cultivated in China and Japan from the very remotest times, and, as it is recorded in the celebrated *Materia Medica* of Shetnon, its cultivation is estimated to date back more than 5,000 years.

In a treatise by Li-Yu-Ying and Grandvoinnet, published in *l'Agriculture pratique des pays chauds*, it is said that numerous ancient documents trace back the invention of soja cheese to the great philosopher, Hainintze, a prince of the Han dynasty.

The soy bean is encountered throughout China and Asia, and has been introduced into the United States and Europe.

It has been studied by a number of writers, and is mentioned by Kaempper in 1690 in his "Amenitatum exoticarum." According to the "Hortus Kewensis" of Aiton, it was introduced into England in 1790; and into Italy in 1848, if we follow Pinolini ("Della Soia"). Since then this plant has spread throughout Europe, and in 1880 soy beans were put on the market by the firm of Vilmorin.

The soy bean is an herbaceous leguminous plant, varying in height according to the variety cultivated. It possesses one peculiarity, and that is that all the pods ripen together, whereas in all other Leguminosæ, flowers, ripe and unripe pods are found simultaneously. The pod, which usually contains three seeds, is villous and measures 4 to 6 cm. in length; occasionally pods are found containing two to five seeds. These seeds vary greatly in colour: yellow, red, brown, black, green, or variegated; their shape is more or less oval.

The root nodules are of fairly noticeable size and contain millions of bacteria, a fact we have established by microscopical examination.

Linnæus classified this plant as *Dolichos Soja,* and it is Moench who has created the genus *Soja*. The Kew index recognizes three species of Soja, classified under the genus *Glycine*:—

(1) Glycine hispida;

(2) Glycine Soja;

(3) Glycine Javanica.

Such characters as the constriction and the partitions, which are absent in *Glycine Soja,* serve to distinguish the species.

More than 400 varieties of Soja are in existence, and in nearly all countries the varieties are classified according to the colour of the seeds. In Japan, according to M. Pailleux, they are classified in various ways; first, according to the precocity of the plant; then, according to the shape of the seed, and, finally, according to the colour.

M. Pierre classifies the Chinese races: (1) Following the colour of the flowers, (2) the shape of the leaflets, and (3) according to the colour of the fruit.

In the United States the varieties are differentiated by the colour of the seeds. As already noted, this is the basis of the principal classifications.

The soy bean may be cultivated everywhere, and the

great secret of its success is to plant the variety best suited to the particular locality.

In Europe, for instance, it was quite unsuccessful until the precocious and quick-growing varieties were tried. This plant may be easily cultivated anywhere, provided a variety or varieties are chosen adapted to the particular climate.

The soy bean is of erect growth and may be sown very closely. In a pure cultivation the rows may be 40 cm. apart and the seeds at intervals of 30 cm. Owing to the aspect of this plant and its not interfering in any way with the small canes, the soy bean may be used in a mixed cultivation, and may even be sown in two rows in interspaces of canes. This is a valuable advantage which should always be kept in mind. Undoubtedly the yield of green manure will be inferior to that of the cow pea or black pea; but, at the same time, this plant has commendable qualities.

The soy bean is not exacting as regards the physical nature of soils. Provided they are not too firm it thrives well nearly everywhere. It is particularly resistant to drought, and gives satisfactory results where the yield of the cow pea would only be small. Its demands from the point of view of the chemical qualities of the soil are fairly large, for it is a rich plant, and abstracts a relatively large proportion of nutritive elements.

As has already been stated in the course of this work, it is not because the Leguminosæ are plants which enrich the soil that they have the capacity of thriving in practically all soils. In order to carry out their function of assimilating atmospheric nitrogen they must be placed in conditions favourable to their complete development, especially when they are cultivated for pulse or green fodder.

This is the case with soy, on which a number of manurial experiments have been made. When phosphatic and potassic manures were applied the yield was increased.

In the treatise by Li-Yu-Ying we get statements of increases in the crop of green fodder of 2,400, 2,600, 5,000,

12,300 kilos, and increases in the yield of seed of 300 and 400 kilos.

In experiments made in South Africa, accounts of which appear in *The Agricultural Journal,* fields without manure are seen to give 4,454 kilos of stems to the hectare, whilst phosphatic and potassic manures brought the yield up to 7,098 kilos. The seed crop amounted to 1,038 kilos to the hectare, without manure, and, with the manures mentioned, to 2,014 kilos.

The yields per acre in India are lower than those obtained in South Africa without manuring. In Lahore, according to the "Report on the Government Agri-horticultural Garden," the yield is 349 lb. of seed per acre. In Madras 468 lb.; Bombay 300 lb.; in Poona, better results are obtained, the yields of seed being 650 to 700 lb. per acre. According to the *Reporter on Economic Products in India,* the yields to the hectare in 1906-7 at the Manjri Farm were:—

Black soil	2,762 lb.
"	1,215 "
"	1,540 "
"	1,362 "
"	935 "

with an average of 1,563 lb.

In the United States the yields recorded have been extremely variable, and trials in several spots have given from 4 to 10 hectolitres of seed per acre.

M. Bonâme calculates from the results of his trials at the Agronomic Station at Mauritius that it should be possible to obtain 16½ to 19 hectolitres of seeds, or 14,200 to 16,600 kilos of green fodder to the hectare, the cultivation being a pure one and not interplanted with canes.

The yields in seeds have been shown to vary according to the species and the conditions of cultivation.

In the tables of yields given by the *Journal de l'Afrique du Sud,* and also by M. Grandvoinnet, the application of nitrogenous manure has been shown to have no result.

The elements abstracted by a crop of soy have been calculated by M. Joulie :—

Elements	1,000 kilos Abstract in kilos			100,000 kilos of crop to the hectare Abstract in kilos		
	Stems and leaves	Seeds	Whole plant	Stems and leaves	Seeds	Total
Nitrogen	12·60	57·88	28·10	82·12	198·89	281·01
Phosphoric acid ...	4·62	17·39	9·02	30·35	59·85	90·20
Lime	43·65	3·28	28·81	286·78	11·29	298·07
Magnesia ...	9·88	8·91	9·36	62·94	30·67	93·61
Potash	9·76	20·29	13·39	64·12	69·84	133·96
Iron	1·27	0·93	1·15	8·34	3·26	11·54
Sulphuric acid ...	2·72	1·41	2·26	—	—	—
Soda	4·13	0·50	2·88	—	—	—
Silica	32·73	1·03	21·83	—	—	—

In the *Journal d'Agriculture pratique,* M. Lechartier gives the following figures for a crop of soy, green fodder :—

	Weight of forage crop	
	20,000 kilos	30,000 kilos
Phosphoric acid	32·0 kgr. ...	48·0 kgr.
Sulphuric acid	34·0 ...	51·0
Lime	125·6 ...	188·4
Magnesia	41·0 ...	62·0
Potash	70·6 ...	105·9
Nitrogen	99·4 ...	149·1

The whole crop yielding in seed :—

Mineral elements	1,000 kilos		1,500 kilos		2,000 kilos
Ash ...	513·50	...	770·30	...	1,027·00
Phosphoric acid	38·85	...	58·20	...	77·70
Sulphuric acid	40·40	...	60·60	...	80·80
Lime ...	167·70	...	251·60	...	335·40
Magnesia ...	58·96	...	88·40	...	117·90
Potash ...	43·21	...	64·80	...	86·40

According to M. Grandeau, the sum of nutritive elements removed by a green crop of soy is :—

	Kilos
Phosphoric acid	32·0 to 48·0
Lime	125·0 ,, 188·0
Magnesia	41·0 ,, 62·0
Potash	71·0 ,, 106·0

The annual report of the Agronomic Station of Mauritius gives the proximate composition of the whole plant to be :—

Water	78·60	per cent.
Ash	1·84	,,
Cellulose	6·80	,,
Fat	0·84	,,
Sugars	0·57	,,
Non-nitrogenous matter	6·90	,,
Nitrogenous matter	4·45	,,
	100·00	

The composition of the seeds varies between fairly wide limits, according to the varieties. In Mauritius the two varieties tested gave very different proportions of fat and nitrogenous matter.

	Yellow per cent.	Green per cent.
Water	7·87	8·36
Ash	4·62	4·64
Cellulose	4·90	4·80
Fat	13·66	19·20
Sugars	9·20	6·10
Non-nitrogenous matter	18·25	24·85
Nitrogenous matter	41·50	32·05
	100·00	100·00

The *Queensland Agricultural Journal* for January, 1911, gives an analysis of the seeds of soy:—

Water	7·70	per cent.
Ash	5·79	,,
Cellulose	4·60	,,
Fat	20·35	,,
Non-nitrogenous matter	26·15	,,
Nitrogenous matter	35·40	,,

We take from the *Indian Trade Journal* the average oil content in fourteen samples of seeds sent from Japan and cultivated on the Manjri Experimental Farm:

Oil, per cent. average	19·54
,, minimum	16·44
,, maximum	22·48

The *Reporter on Economic Products* at Calcutta has established comparisons between soy seeds harvested in different portions of the world, and credits them with the following oil contents:—

Beans from China	17·60	to	26·18	per cent.
,, Japan	13·36	,,	25·55	,,
,, Java	18·37	,,	26·18	,,
,, Europe	15·16	,,	21·89	,,
,, North America	18·42	,,	19·52	,,

Church, in "Food Grains of India," attributes to soy beans the following composition :—

Water	11·00 per cent.
Ash	4·60 ,,
Cellulose	4·20 ,,
Fat	18·90 ,,
Sugars and starch	26·00 ,,
Nitrogenous matter	35·30 ,,
	100·00

König, in the first of his volumes, pp. 595-600, states that soy seeds contain :—

Water...	8·00 per cent.
Ash	5·00 ,,
Cellulose	5·00 ,,
Fat	18.00 ,,
Non-nitrogenous matter	28·00 ,,
Nitrogenous matter	36·00 ,,
	100·00

The conclusion derived from these results is that the proportion of nitrogenous matter is apparently more constant than the proportion of fat.

The seeds of the soy bean are not, strictly speaking, oleaginous, as their oil content scarcely exceeds an average of 20 per cent., whilst that of decorticated pea-nuts is higher than 40 per cent.

The mineral composition of the seeds varies according to the variety, and the limits of difference in certain elements are fairly wide. We append, herewith, analyses of soy ash made by M. H. Pellet :—

	First sample	Second sample	Third sample
Carbonic acid ...	1·70	1·20	1·00
Phosphoric acid	29·13	31·92	31·68
Sulphuric acid...	1·37	4·80	2·74
Chlorine	0·75	0·75	0·75
Potash	45·02	45·27	45·02
Lime...	8·92	6·50	4·48
Magnesia	8·19	6·48	8·47
Insoluble matter	1·10	1·10	1·20
Traces NaO-FeO	1·59	2·15	4·83
	100·17	100·17	100·17
To be deducted per cent. for the chlorine	0·17	0·17	0·17
	100·00	100·00	100·00

M. Lechartier has investigated the different portions of the soy bean and their mineral and organic contents.

The following proportions were found in the different parts of the plant :—

	No. 1 per cent.	No. 2 per cent.	No. 3 per cent.	Average per cent.
Stems	27·13	23·12	26·82	25·45
Leaves	35·00	42·44	42·72	40·18
Pods	37·87	34·44	30·46	34·37

	Green soy			Dry soy		
	Stems	Leaves	Pods	Stems	Leaves	Pods
Water...	72·47	73·33	75·86	—	—	—
Total nitrogen ...	0·21	0·46	0·76	0·76	1·71	3·14
Crude protein ...	1·31	2·84	4·78	4·76	10·71	19·65
Nutritive nitrogenous matter	0·86	2·40	4·01	3·11	9·02	16·53
Amides expressed in asparagin	0·34	0·35	0·57	1·26	1·30	2·36
Fat ...	0·29	1·04	1·65	1·06	3·92	6·85
Matters capable of conversion into sugar	8·57	5·91	6·80	31·11	22·15	28·15
Nitrogen-free extract ...	5·05	8·90	4·12	18·36	33·37	16·78
Cellulose (woody) ...	11·10	4·79	5·44	40·29	17·93	22·58
Ash ...	1·32	3·28	1·55	4·81	12·31	6·45

NUTRITIVE ELEMENTS CONTAINED IN EACH PORTION OF THE PLANT (LECHARTIER).

	In the green state				In the dry state			
	Stems	Leaves	Pods	Whole plant	Stems	Leaves	Pods	Whole plant
Proportion ...	25·45	40·18	34·37	—	26·87	41·33	31·78	—
Water ...	18·62	29·38	25·98	73·98	—	—	- -	—
Total nitrogen ...	0·05	0·19	0·26	0·50	0·21	0·71	1·00	1·92
Crude protein ...	0·34	1·15	1·63	3·12	1·29	4·43	6·24	11·96
Nutritive nitrogenous matter	0·27	1·03	1·38	2·63	0·83	3·98	5·29	10·10
Amides (asparagin) ...	—	0·14	0·18	0·41	0·34	0·53	0·82	1·69
Fat ...	0·07	0·42	0·57	1·06	0·28	1·62	2·18	4·08
Matter capable of conversion into sugar	2·19	2·39	2·34	6·92	8·29	9·25	8·98	26·52
Nitrogen-free extract...	1·33	3·49	1·38	6·20	5·01	13·50	5·29	23·80
Cellulose (woody) ...	2·84	1·91	1·87	6·62	10·81	7·39	7·48	25·38
Ash ...	—	—	—	—	1·29	5·09	2·08	8·46

The mineral elements in the different parts of the plant have also been apportioned by M. Lechartier.

TOTAL WEIGHT OF MINERAL MATTER FURNISHED BY 1,000 KILOS OF DRY FODDER.

Mineral elements	Stems	Leaves	Pods	Whole plant
Proportion ...	26·80	41·15	31·79	—
Ash ...	12·91	50·87	20·50	84·28
Silica ...	0.·07	1·46	0·12	1·65
Phosphoric acid ...	1·24	1·58	3·33	6·14
Sulphuric acid ...	2·24	2·61	1·71	6·56
Lime...	3·35	18·37	2·47	24·17
Magnesia ...	1,91	5·40	2·16	9·47
Potash ...	2·13	4·01	7·45	13·59
Soda ...	0·20	0·07	0·89	1·16
Nitrogen ...	2·05	7·08	10·00	19·13

In the East Indies the oil extracted from soy is used on a large scale for food purposes. It has a number of other uses as well; for instance, in China it is used for lighting purposes, and, as it is a drying oil, may also be used in the manufacture of paint. In Europe, as in Eastern Asia, it enters into the manufacture of soaps, and is also used as machine oil; recently it has been converted into margarine. The digestibility of this oil has been studied in 1906 by Korentschewski and Zimmermann, the co-efficient of digestibility being found almost equal to 95 per cent.

In 1905 Zimmermann found the properties and composition of this oil to be as follows:—

Water	...	0·3	to 1·8 per cent.
Density at 15° C....	...	0·9264	„ 0·9287
Solidification point	...	14·6	„ 15·3° C.
Saponification ...	...	207·9	„ 212·6
Fatty acids ...	...	93·6	„ 94·3

It consists chiefly of glycerines, palmitic and oleic oils.

The cake, formed from the residue after oil extraction, is a first-class food for live stock. It is extremely concentrated, and should therefore be given with care.

The *Agricultural Gazette of New South Wales* gives an analysis:—

Water	14·52	per cent.
Ash	5·16	„
Cellulose	4·03	„
Fat	8·73	„
Non-nitrogenous matter	25·25	„
Nitrogenous matter	42·31	„
	100·00	

The nutritive ratio is 1 to 1·06, whilst the nutritive value is 87·3.

This cake may also be used as manure, as it is rich in potash, phosphoric acid, and nitrogen.

Nitrogen	6·77	per cent.
Potash	2·00	„
Phosphoric acid	1·33	„

The seed of the soy bean is eaten as a vegetable by the majority of the Chinese and Japanese, and they make

numerous other uses of it. We append the chief of these uses herewith :—

Soy Milk.—The seeds are first allowed to soak in water for about eleven hours, and are then crushed with a stone. The powder is then boiled for an hour in about three times its volume of water and filtered through a cloth. The filtrate is the soy milk, a liquid of high nitrogen content, but unsuited to children.

Soy Cheese.—To make soy cheese the milk obtained is treated with chloride of magnesia. The protein matters are precipitated; they are then collected by means of a filter; dried, and pressed.

Shoyu. Shoyu is a sauce prepared with a mixture of seeds (cooked and crushed, washed, and powdered with flour), flour of wheat, salt and water. This mass is placed in barrels and allowed to ferment for one and a half to five years with ferment of rice and wine, and is stirred at frequent intervals. The result is a thick brown liquid.

The roasted seeds of the soy bean are used in the United States and Switzerland as a substitute for coffee.

Not containing any starch, these beans are used in the manufacture of breads and biscuits for people suffering from diabetes. They are found on the European market.

It should be explained that the whole of the exports to Europe are not intended for human consumption, as, on account of its peculiar flavour, soy is a vegetable for which it is difficult to acquire a taste. The seeds are pressed in order to extract the oil, the oil resulting from the first expression being used in the manufacture of soap, whilst that from the second is used as machine oil.

The cake is given to cattle mixed with other nutriments of lower nitrogen content.

The trade in soy has increased considerably during the last five years. In 1907 the annual export from Manchuria, the principal centre, did not exceed 120,000 tons. In 1908 the total rose to 330,000 tons, the increase being due simply

to the European demand. In 1909 Europe imported 700,000 to 800,000 tons, and it is expected to reach a total of 1,000,000 tons.

These products are sold on the London market, the seeds at £5 to £6 per ton; the oil costs £21 to £22 per ton, and the cake fetches £6 to £7 per ton.

TEPHROSIA CANDIDA.

The indigo-yielding plant used in rotations belongs to the genus *Tephrosia* (from the Greek *Tephros,* ashy; referring to the colour of the leaves). The most commonly distributed species are *Tephrosia candida* and *Tephrosia purpurea*. The latter is a native of the East Indies, and was discovered in 1768. If this plant is preferred to the Lima bean or other leguminous species, the reason is because the former, when cut to allow of the soil being put into cultivation, furnishes an appreciable amount of fuel.

From the chemical point of view, we are of the opinion that, being a shrub, it extends its roots deeper into the subsoil, and consequently brings to the surface of the fields, after the leaves have decomposed, a larger quantity of mineral elements. At the same time it must be pointed out that, as regards its value as a rotation crop, this end is not completely attained, for the removal of the stems is the cause of a certain impoverishment of the soil.

The actual proportion of stems in *Tephrosia candida* is 60 to 65 per cent., with a content of mineral matter of 1·9 per cent. We must take it that the owner finds compensation for this loss in the wood used for fuel.

We have no figures to allow of our establishing the amount of yield to the hectare.

If this plant affords an actual profit from the special point of view as a rotation crop, it can only be attributed to the numerous leaves which fall and cover the soil during growth and to the specialization of the roots which, penetrating more

deeply, abstract the fertilizing elements from the subsoil as well as from the upper layer. If the owner finds it useful to employ the branches as fuel, the loss may be made good by returning the ashes to the fields. In that case the nitrogen, being lost for the most part to the atmosphere, must be neglected.

Some planters, after the branches have been cut, burn the leaves and twigs that remain on the fields, but this method is not to be recommended, the losses incurred thereby outweighing the advantages.

Appended is the mineral composition of the stems and leaves of *Tephrosia candida*.

STEMS.

	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of stems
Silica	2·44	0·041	0·016
Chlorine	1·27	0·080	0·031
Sulphuric acid	2·46	0·085	0·033
Phosphoric acid	4·33	0·368	0·143
Lime	26·82	1·251	0·486
Magnesia	12·69	0·163	0·063
Potash	20·80	1·541	0·598
Soda	0·70	0·082	0·032
Oxide of iron	0·64	0·047	0·018
Carbonic acid, &c.	27·85	1·262	0·490
	100·00	4·920	1·910

These figures show that, as in other Leguminosæ, the chief minerals in this plant are lime, potash, and magnesia.

LEAVES.

	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of leaves
Silica	0·84	0·359	0·087
Chlorine	1·63	0·187	0·046
Sulphuric acid	1·72	0·362	0·089
Phosphoric acid	7·48	0·637	0·157
Lime	25·42	3·943	0·971
Magnesia	3·32	1·864	0·459
Potash	31·32	3·058	0·753
Soda	1·66	0·103	0·025
Oxide of iron	0·96	0·094	0·023
Carbonic acid, &c.	25·65	4·093	1·010
	100·00	14·700	3·620

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[Photo by G. Rêhaut.

FIG. 29.—*Tephrosia candida*. Stems and fruit.

It is to be noticed that the leaves contain a larger amount of potash and phosphoric acid and a much higher proportion of mineral matter. Consequently, when they remain on the fields they return all the mineral salts withdrawn from the soil, and on rotting they form humus, which enriches it in organic matter as well.

GREEN STEMS AND LEAVES.

	In 100 parts of leaves	In 100 parts of stems	Total per cent.
Silica	0·033	0·010	0·043
Chlorine	0·017	0·019	0·036
Sulphuric acid... ...	0·033	0·021	0·054
Phosphoric acid ...	0·059	0·089	0·148
Lime	0·365	0·303	0·668
Magnesia	0·173	0·040	0·213
Potash	0·283	0·373	0·656
Soda	0·010	0·020	0·030
Oxide of iron	0·009	0·011	0·020
Carbonic acid, &c. ...	0·379	0·306	0·685
	1·361	1·192	2·553
Nitrogen	0·263	0·212	0·475
Dry matter	9·27	24·27	33·54
Proportion	37·6	62·4	100·0

The mineral content of the dry matter being of interest the figures we obtained are appended herewith :—

DRY STEMS AND LEAVES.

	Per cent.
Silica	0·128
Chlorine	0·107
Sulphuric acid	0·161
Phosphoric acid	0·441
Lime	1·991
Magnesia	0·635
Potash	1·955
Soda	0·089
Oxide of iron	0·060
Carbonic acid, &c.	2·041
	7·608
Nitrogen	1·415

1,000 kilos of these branches thus remove 19·10 kilos of mineral matter, the principal elements being apportioned as follows :—

Lime	4·86 kilos
Magnesia	0·63 ,,
Potash	5·98 ,,
Phosphoric acid	1·43 ,,

As has been already mentioned, these losses may be avoided by returning the ashes to the fields.

However that may be, failing special local conditions, we do not think *Tephrosia candida* can rival the pea as a restorative plant.

In 1897 M. Bonâme, who has always been prominent in calling attention to the advantages to be derived from our various plants, advocated the use of these seeds for feeding live stock. In spite of their being reputed poisonous in Mauritius, they are largely used in Réunion for feeding cows and pigs.

They are easy to harvest, and their cost price is much lower than that of Indian seeds.

We give their composition herewith :—

Water	13·40	per cent.
Ash	4·82	,,
Cellulose	13·65	,,
Fat	8·50	,,
Non-nitrogenous matter	25·88	,,
Nitrogenous matter	33·75	,,
	100·00	

Although the husks make a coarse fodder on account of their high cellulose content, they might be used crushed up with other foods, or as an absorbent for molasses.

The following analysis was made by M. Bonâme in 1897 :-

Water	10·36	per cent.
Ash	1·60	,,
Cellulose	42·70	,,
Fat	0·36	,,
Non-nitrogenous matter	39·61	,,
Nitrogenous matter	5·37	,,
	100·00	

Tephrosia candida is sown at the beginning of the winter season, *i.e.*, with the first rains. The seeds are sown in pairs at intervals of 1 metre. The rows should also be 1 metre apart. Three months after sowing the plant begins to bloom, and is then from 3 to 3½ ft. high.

The root system is considerably ramified, and the roots reach down beneath the subsoil with more or less numerous

FIG. 30. *Tephrosia Vogelii.* Stems, flowers and fruit.

nodules, according to the variety sown and the conditions of cultivation. For instance, *Tephrosia purpurea* gives more

nodules than *Tephrosia candida*. When fully developed it reaches a height of 3 to 3½ metres.

The pods are generally picked before the stems are cut. They are then put into sacks and beaten in order to obtain the seeds, which easily retain their germinative power for a whole year.

The species of *Tephrosia* are known by different names, according to the countries where they are cultivated. In the Mascarenes the plant is called *l'indigo sauvage;* in Ceylon it is known as *Boja Medelloa;* this would be *Tephrosia candida*, whilst in Ceylon *Tephrosia purpurea* is called *Kavalai.*

In the East Indies it has given extremely satisfactory results as a green manure. Mr. J. C. Moore, Director of Agriculture at St. Lucia, says that *Tephrosia candida* appears to be the best dressing manure for cacaos and limes, although practical application of it on other crops should first be made under the same circumstances as for the cacao.

Tephrosia purpurea has been employed in Ceylon as a green manure, and the following analyses are given in the "Progress Report" of the Agricultural Society:—

The branches, leaves, and tops of samples dried in the sun yielded 64·6 per cent., and the roots 44·9 per cent. of water.

These dried samples gave when analysed:—

	In 100 parts of branches, leaves and tops	In 100 parts of roots
Water	17·50	12·50
Organic matter	78·85	84·75
Nitrogen	2·24	0·84
Ash	3·65	2·75

The analyses of ash of the entire plant give percentages: Of lime, 28·00; magnesia, 14·40; potash, 11·96; phosphoric acid, 16·00.

Finally, we append the proportion of nitrogen in leaves and branches:—

	In 100 parts of leaves		In 100 parts of branches		Total per cent.
Nitrogen	3·47	...	1·76	...	2·75
,, in a dried sample	3·73	...	1·87	...	2.94

The mineral analysis made in Ceylon shows a much lower proportion of potash than that which we found in Mauritius, while the phosphoric acid content is higher.

[*Photo by Desruisseaux.*

FIG. 31.—Plant of *Tephrosia Vogelii.* Anjouan.

This is perhaps due to the species (*purpurea*) requiring less potash than the Mauritian species (*candida*).

Besides these two varieties there are a number of others which are of no importance from the agricultural point of view.

It is advisable to record that a number of these plants are poisonous. For instance, in Tahiti is found *Tephrosia piscatoria*, which, though eaten greedily by cattle, is poisonous to poultry. Lanessan informs us that the branches and leaves of this species, when thrown into streams, kill the fish, acting on them in the same way as digitaline, but without rendering them inedible.

In Senegal there occurs *Tephrosia linearis*; in Guiana *Tephrosia piscatoria* is known as *Toxicaria*, and in Senegal as *Vogelii*. The properties of these three are the same.

[*Sketch by P. A. Desruisseaux.*

FIG. 32.—Branch of the Wild Indigo Plant of Anjouan (Comoros).

M. Advisse Desruisseaux communicates to us that in Anjouan a wild indigo plant is found which lives for several years. The stem attains a diameter of 3 to 4 cm. and turns a reddish brown. In dry situations this plant only lives for one year. It forms a thick blanket, sprouting at the commencement of the rains and disappearing some time after the dry season.

In suitable climates this shrub may live for several years, and has this advantage over the wild indigo (*Tephrosia candida*) used in rotations, in Mauritius, that its foliage is thicker and more extensive.

In Anjouan the natives make use of the leaves of *Tephrosia Vogelii*, which probably contain a stupefactive poison, for fishing. The bruised leaves are thrown into the water, and the dazed fish are then easily caught.

WILD INDIGO PLANT OF ANJOUAN.

	In 100 parts of dry matter	In 100 parts of natural substance
Water ...		73·90
Ash ...	10·1	2·64
Nitrogen	4·12	1·07

	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of natural substance
Sulphuric acid	0·73	0·074	0·019
Phosphoric acid	7·34	0·741	0·194
Lime ...	26·54	2·680	0·700
Magnesia	7·00	0·707	0·185
Potash ...	26·39	2·665	0·696
Soda ...	0·23	0·023	0·006
Oxide of iron	0·33	0·033	0·008

VICIA FABA (BEAN).

This bean has been known from the remotest times. It has been recorded by Ezekiel, David, and Samuel, and was introduced into China by the Emperor Chin-Nong 2,822 years before the Christian era.

In Greece this legume was used in the Eleusinian fêtes that were celebrated yearly in the magnificent Temple of Ceres, built by Pericles. The Romans also regarded the bean as a food plant. According to Pliny, the flour it yielded was called *Lomentum fabacum* and in conjunction with the flour of wheat and millet was used in the manufacture of bread.

In Paris, in the sixteenth century, small beans in their immature state were the subject of competition on the

markets. During this same period important banquets, known as *champeaux,* were given at which it was always the custom to serve beans.

In Europe, Egypt and Arabia this plant is thus historical. At the present day the bean is cultivated in Europe, Egypt, China, Java, Japan, America, the Sudan, Madagascar, &c. According to de Candolle, its introduction into India is only recent.

In Mauritius the bean with the widest distribution is the one commonly known as *bocla,* or in India *bacla.* It is identical with the common bean, *Vicia Faba* or *Faba vulgaris.*

No mention is made of it by Cossigny, and we may take it that it has been brought to Mauritius from India by the numerous Indian immigrants.

Beans are annual plants from 40 to 80 cm. high or sometimes even higher, the stems are simple and very rarely branched at the summit. The flowers they bear are axillary racemes, shortly pedunculate. The pods are sessile, bulky, swollen, pubescent, green, and lined internally with a kind of felted down. The shape and size of these pods vary greatly in the different races. In the common bean they are fairly short, almost cylindrical and erect; in other varieties they are sometimes curved, short, and broad, and sometimes considerably elongated, and may reach a length of 35 to 40 cm.

Similarly with the size of the seeds in the different varieties. They are generally flattened on the surface, greenish white, green, or violet in colour. According to certain writers they retain their germinative capacity for exceedingly long periods, averaging from six years, with a maximum of ten years.

Distinction is made between two series of varieties: horse beans (*Faba vulgaris*) and beans properly so-called. The former are usually cultivated for live stock, their flavour being considerably less agreeable than that of the vegetable

races. The horse bean (*féverole*) resembles more the primitive plant, and its seed is not used as a vegetable.

In India, Mauritius, and a number of other tropical countries the bean most frequently met with is the horse bean, *Faba vulgaris*. This plant is suited to nearly all soils, provided they are not too close; it thrives without difficulty, but its development will depend on the conditions of cultivation. Usually from 75 to 80 cm. high, it may attain a height of 1·50 metres and will form a very important supply of fodder. Horse beans are extremely valuable plants; they are sown, like all other Leguminosæ, at the commencement of the rainy season. The seeding may be very close, the plants being upright and very little branched. It is regrettable that they are not utilized through canes; they might be sown in three rows in each interspace, and the total of green matter ploughed in at the period of flowering would be very considerable.

The variety that has come to us from India is a plant with single stem; the leaves are oblong, lanceolate, and extend along the whole length of the plant. The flowers are spread in clusters at the summit, and are black and white.

This plant is but little cultivated in Mauritius, and only small plots are found. It is chiefly the Indians who grow it, round about their dwellings, and it only very exceptionally appears on the market.

As has been already mentioned, this plant might be an extremely valuable one for rural industry. If interplanted through canes the seeds might be picked and given to live stock; this would be of all the more advantage in view of the difficulty of feeding live stock, and a locally grown nutriment would pay well. The seeds are in the proportion of 80 to 85 per cent. They are very rich in nitrogenous matter, contain but little cellulose, and form a first-class nutriment.

The composition of these horse beans is as follows:—

Water	12·25	per cent.
Ash	2·66	,,
Cellulose	7·05	,,
Fat	1·17	,,
Non-nitrogenous matter	51·05	,,
Nitrogenous matter	25·82	,,
	100·00	
Nitrogen	4·13	,,

M. Balland gives elsewhere ("Les Aliments") the following limits of composition for common beans:—

	Minimum per cent.	Maximum
Water	10·60	15·30
Ash	2·06	3·26
Cellulose	5·24	7·86
Fat	0·80	1·50
Non-nitrogenous matter	50·89	58·03
Nitrogenous matter	20·87	26·51

In M. Denaiffe's work ("Les Haricots") we find two comparative analyses of the French and common bean.

	In 100 parts of common bean	In 100 parts of French bean
Water	14·80	15·00
Nitrogenous matter	26·30	26·90
Fat	2·20	3·00
Sugars and starch	49·50	48·80
Cellulose	3·70	2·80
Ash	3·50	3·50
	100·00	100·00

This table proves the nutritive value of the common bean to be the same as that of the French bean, and in comparing these results with those of the horse bean scarcely any difference is found among common beans, horse beans, and haricot beans. The question of taste must thus be the deciding factor, and the somewhat strong, peculiar flavour of the horse bean is doubtless the only cause of its rejection as a table vegetable.

Notwithstanding, it might be used to considerable advantage in a mixed cultivation, either to be ploughed in when in flower or to be harvested as a seed crop for animal fodder.

The weight of the seeds for all varieties of beans is not identical, as may be seen from the following abstracts from M. Balland's book :—

	Average weight of 100 seeds in grm.	Seeds per cent.
Algeria	91·10 ..	85·2
New Caledonia	151·60 ...	84·9
Tunis	181·80 ...	—
Egypt	65·50 ...	86·4

The husks, which are in a proportion of 15 to 16 per cent., have the following composition :—

	Mauritius, per cent.	Tunis, per cent.	Egypt, per cent.
Water	11·65 ...	10·90 ...	10·20
Ash...	2·77 ...	2·90 ...	2·60
Cellulose	41·30 ...	39·86 ...	40·50
Fat	0·55 ...	0·12 ...	0·70
Non-nitrogenous matter	38·58 ...	39·84 ...	42·86
Nitrogenous matter ...	5·15 ...	6·38 ...	3·14
	100·00	100·00	100·00

The axial portions of the embryos are very rich in nitrogen, and 100 weigh 2·78 grm.

Water...	8·00 per cent.
Ash	3·80 ,,
Cellulose	0·62 ,,
Fat	4·20 ,,
Non-nitrogenous matter ...	42·58 ,,
Nitrogenous matter	40·80 ,,
	100·00

The decorticated beans are used to prepare a food flour. This flour contains :—

Water...	12·40 per cent.
Ash	1·80 ,,
Cellulose	1·50 ,,
Fat	1·54 ,,
Non-nitrogenous matter	57·27 ,,
Nitrogenous matter	25·49 ,,
	100·00

The acid content may lie between 0·05 and 0·09 per cent. The bean is attacked by one of the Hemiptera, *Aphis sp.* This insect is perfectly black and has transparent wings. It

lives by piercing the tissues of the plant with its rostrum, of trunk-like dimensions, and sucking up the sap in a continuous stream. It can be extremely injurious.

VIGNA CATJANG (COWPEA).

(*Vigna Catjang*, dedicated to Dominica Vigna, commentator of Theophrastus.)

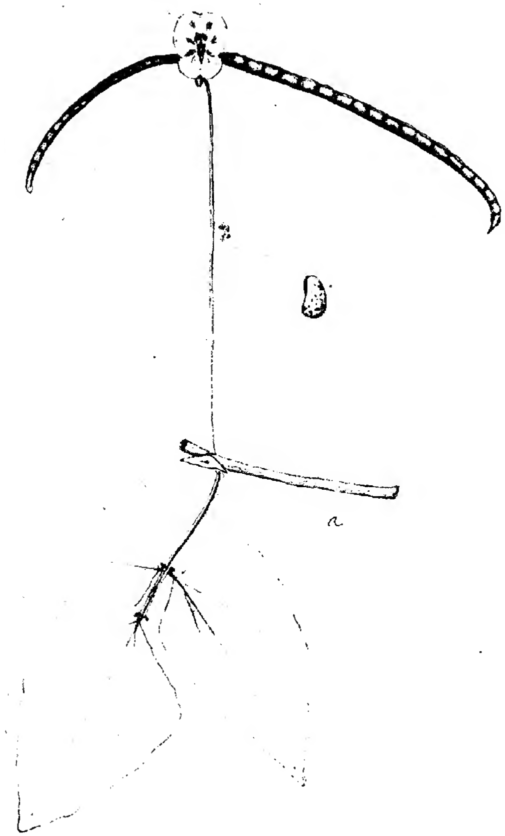
In the islands of the East three varieties of Phaseoli are cultivated. They are varieties of *Dolichos catjang*, which is said to be a native of Madagascar. According to Jacques and Henricq's "Manuel des Plantes," *Vigna Catjang* was discovered in 1793 in the East Indies.

There are a number of varieties in existence, and the Experimental Station of Arkansas (U.S.A.) counts as many as twenty-five to thirty varieties of cowpea which are the subject of numerous experiments.

Some varieties of the cowpea are trailing plants and others non-trailing. It may be used either as a pure or a mixed crop. Its cultivation has been extended enormously in Australia and America, being particularly widely spread in Queensland, where it is used almost exclusively as a restorative crop.

The trailing varieties should be used in land under rotations, whilst between canes the non-trailing varieties are preferable. At the same time, in order to ensure their full development, they should be sown whilst the canes are still small and have not yet taken possession of the land, their chief advantage being that they cover bare soil unoccupied by the vegetation of the canes.

Further, the development of these plants will vary according to the period of sowing. They will attain their largest size if the seeding is carried out immediately at the commencement of the rains; that is to say, in December in Mauritius, or at the beginning of the winter season.



[Sketch by P. A. Desruisseaux.

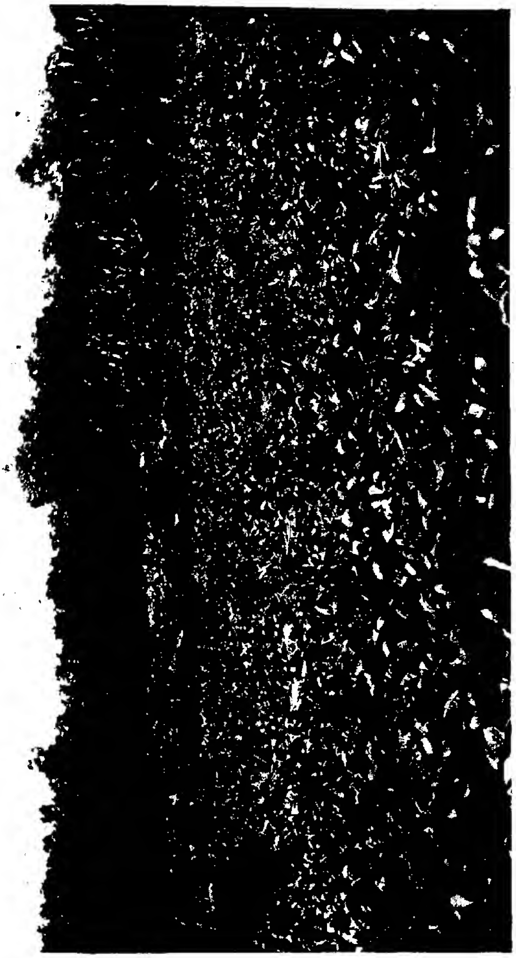
FIG. 33. Cowpeas (*Vigna Catjang*). *a*, leaf and inflorescence; *b*, seed (natural size).

The cowpea might be planted at any time of the year, but owing to the attacks of the bean-fly *Agromyza*, which in certain months of the year ravages the cowpea as well as all other Phaseoli, the time of sowing must be chosen with discrimination. This insect is found to a certain extent everywhere, and the only months when it disappears, or, rather, during which its action is very much weakened, are, in Mauritius, from October to February-March.

Every portion of the cowpea plant may be utilized. It is generally sold and eaten in the dry seed state, but its cultivation might acquire considerable importance for consumption in the green state; the pods if picked before mature might make a perfect substitute for French beans as a table vegetable. M. Bonâme has estimated that more than 16,500 lb. of green pods might be harvested to the hectare, and, in addition, there would be the stems as fodder for live stock.

Viewed from no matter what standpoint the cowpea should play a very important part in crop rotations. It is said that it does not thrive everywhere, notwithstanding the fact that in America it is cultivated under most varied climates. It is suited to every soil, as, like all Leguminosæ, it has the property of enriching the soil in nitrogen. Mr. Smith, of the United States Agricultural Department, calls it, in his report for 1896, "the poor man's bank." It should be noted, however, that the maximum of yield and development will depend upon the conditions of cultivation. If it is planted for a crop of green manure it should be ploughed under immediately it begins to bloom. When cut before that period the stems furnish a superior quality forage, which may be either used green or dried for keeping purposes. If the object of the cultivation is a seed crop the dead leaves will do for fodder, but they are only employed as such in countries where the feeding of live stock is difficult.

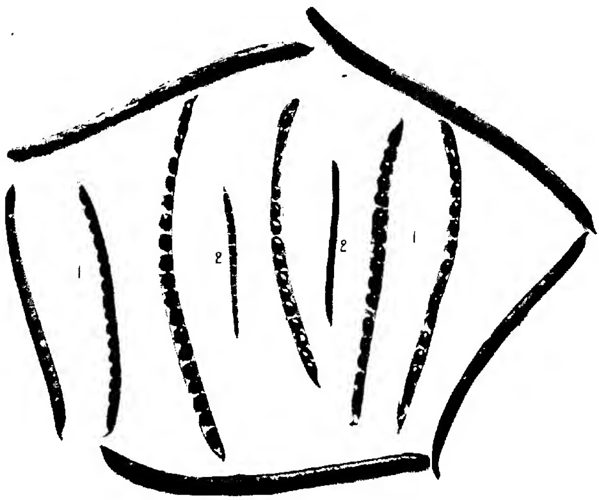
The seeds are consumed either husked or in the dry state; India and Madagascar export large numbers.



[*Photo by G. Réhaut.*

FIG. 34.—Cowpeas (*Vigna Catjang*) as a rotation crop at Réduit (Mauritius).

The seeds may be sown for a pure crop at intervals of 0·66 metre, and will then give a better yield than if sown at intervals of 1 metre, and a better one still if only one plant of each pair be allowed to remain. The results we obtained in a trial at Saint Hubert, on the Grand Port sugar plantation, of several rotation peas, have been arranged in a table which we reproduce further on. They clearly prove that in a pure cultivation the best plan is to sow at intervals of 0·66 metre, and only to leave one plant in each hole.



[*Photo by G. Rehaut.*

FIG. 35.—1, Dry pods of different species of Cow Peas; 2, dry pods of Ambérique.

In a mixed cultivation through canes, either in every row or in every second row, the planting may be from 60 to 70 cm. apart, and although it is usually preferable to sow single plants only, in this case three seeds are sown and the three plants are allowed to remain, the main object being to cover the ground rapidly in order to avoid the growth of

weeds. The plants should be protected from weeds when young in order that they may put up a better fight and fulfil their object.

In a few trials made at Réduit as an inter-crop with canes, M. Bonâme has obtained, in two and a half to three months, the following quantities of seeds to the hectare from the varieties specified (every other row):—

White cowpeas	270 kilos
Grey Madagascar cowpeas	405 ,,
Black cowpeas	182 ,,

The proportion of seeds being about 75 per cent. of the weight of the full pods, the weight of pods to the hectare was, respectively, 360, 540, 244 kilos.

The composition of the seeds is as follows:—

Trailing varieties	Water	Ash	Cellulose	Fat	Sugars	Non-nitrogenous matter	Nitrogenous matter	Nitrogen	N.M. / N.N.M.
Cowpeas, Réduit ...	11·20	3·54	6·90	1·18	4·50	46·43	26·25	4·20	1·97
,, Madagascar ...	13·71	3·43	4·80	1·26	4·16	50·14	22·50	3·60	2·46
,, Bourbon ...	14·17	3·20	4·30	1·26	3·20	50·75	23·13	3·70	2·38
Vigna glabra	9·08	3·90	0·95	1·28	0·40	47·03	25·36	3·77	2·22
Non-trailing varieties									
Grey cowpeas, Madagascar	12·58	3·40	4·67	0·98	3·70	54·17	20·50	3·28	2·87
Black ,, ,,	11·44	3·58	5·10	1·52	3·28	53·15	21·93	3·51	2·64
White ,, ,,	13·42	3·50	6·75	0·99	5·12	46·01	24·18	3·87	2·15
,, ,, India ...	13·74	3·24	3·80	1·38	4·12	40·91	23·81	3·81	2·32
Iron ,, ...	10·80	3·80	6·35	1·24	5·60	46·84	25·37	4·06	2·11
Porto ,, ...	10·38	3·38	6·00	1·16	5·08	49·90	23·50	3·76	2·41

The husks show the following composition:—

	White cow peas	Grey cow peas
Water	15·61	11·10
Ash	3·34	3·31
Cellulose	36·00	40·00
Fat	1·44	0·82
Sugars	—	—
Non-nitrogenous matter ...	37·52	36·90
Nitrogenous matter	6·06	7·87
	100·00	100·00
Nitrogen	0·97	1·26

These husks may be used for fodder either as an absorbent after being ground, or even mixed with other foods.

The chief mineral elements are lime, magnesia, and potash, whilst in the seeds it is potash and phosphoric acid which especially predominate.

We append herewith the figures obtained from green and grey Madagascan cowpeas:—

DRIED HUSKS.

	White		Grey	
	In 100 parts of ash	In 100 parts of husks	In 100 parts of ash	In 100 parts of husks
Silica	2·35	0·078	2·10	0·069
Chlorine	1·42	0·047	1·02	0·034
Sulphuric acid	1·73	0·057	1·46	0·048
Phosphoric acid	7·60	0·253	5·58	0·185
Lime	20·05	0·669	19·38	0·641
Magnesia	16·54	0·552	16·75	0·554
Potash	25·48	0·850	25·82	0·854
Soda	1·37	0·045	1·50	0·050
Oxide of iron	1·24	0·041	1·26	0·042
Carbonic acid, &c.	22·22	0·748	25·13	0·833
	100·00	3·340	100·00	3·310

As may be seen, there is little or no difference in the composition of the husks of these two varieties of cowpeas. Analyses of other varieties might or might not give similar results to these. However, in relating these figures to the whole crop, a difference of more than 500 grm. is recorded in the case of the grey variety.

DECORTICATED SEEDS.

	White		Grey	
	In 100 parts of ash	In 100 parts of seeds	In 100 parts of ash	In 100 parts of seeds
Silica	0·76	0·028	0·42	0·016
Chlorine	0·76	0·028	1·05	0·041
Sulphuric acid	2·47	0·092	2·96	0·116
Phosphoric acid	25·77	0·964	24·66	0·964
Lime	4·47	0·167	3·12	0·122
Magnesia	8·02	0·300	9·03	0·353
Potash	44·30	1·657	46·33	1·811
Soda	3·03	0·113	4·34	0·170
Oxide of iron	0·34	0·013	0·56	0·022
Carbonic acid, &c.	10·08	0·378	7·53	0·295
	100·00	3·740	100·00	3·910

Unlike the pods, the seeds show dissimilar proportions of potash, lime, phosphoric acid, &c., and these differences,

[*Photo by F. de Sornay.*

FIG. 36.—Indians gathering pods of Cowpeas at the Agronomic Station, Réduit (Mauritius).

when expressed in terms of the whole crop, are still further accentuated.

COMPOSITION OF THE CROP.

	White			Grey		
	Husks kilos	Seeds kilos	Whole fruit kilos	Husks kilos	Seeds kilos	Whole fruit kilos
Silica ...	0·030	0·032	0·062	0·039	0·027	0·066
Chlorine ...	0·017	0·032	0·049	0·019	0·070	0·089
Sulphuric acid	0·021	0·105	0·126	0·027	0·198	0·225
Phosphoric acid	0·096	1·100	1·196	0·105	1·648	1·753
Lime ...	0·254	0·190	0·444	0·365	0·218	0·583
Magnesia ...	0·210	0·342	0·552	0·316	0·603	0·919
Potash ...	0·321	1·889	2·210	0·486	3·097	3·583
Soda ...	0·017	0·129	0·146	0·094	0·291	0·385
Oxide of iron	0·015	0·015	0·030	0·024	0·037	0·061
Carbonic acid, &c. ...	0·288	0·429	0·715	0·412	0·497	0·909
Total mineral matter ...	1·269	4·263	5·530	1·887	6·686	8·573
Crop ...	38·0	114·0	152·0	57·0	171·0	228·0
Nitrogen ...	0·368	3·87	4·238	0·72	6·46	7·18

The differences which we have established need occasion no surprise when we take into account the fact that the vegetation and productivity vary considerably in the two varieties. The grey variety, in fact, is one of those which develop best, producing fine seeds and a higher yield on the fields. In the Saint Hubert trials previously quoted the grey cow pea gave the best green crop.

As already mentioned, the plants form an excellent fodder if cut before flowering, but, generally speaking, they are not used in that way. They are either ploughed in during the flowering period or a seed crop is taken. In the latter case they cannot really be called a restorative crop because of the mineral elements abstracted by the pods. This, however, is balanced by the fact that the seeds form a very valuable nutritive substance on account of their high protein content. We should also take into account the stems and leaves remaining on the fields, which, though not equivalent to the fertilizing elements of a green manure, still mean a more than negligible contribution to the soil.

In Australia, where considerable use is made of the cow pea, it has been found to be a plant which withstands drought remarkably well and gives remarkable results. Like all cover peas, the cowpea retains soil humidity by interception of the solar rays, and consequently prevents evaporation of the soil moisture.

In Australia, in a pure cultivation, a good yield is from 12 to 14 tons of green manure to the acre. A bigger yield may be had according to seasonal and cultural conditions; in the experimental fields established at Saint Hubert by M. de Villèle we have obtained from 25 to 30 tons.

Mr. A. H. E. MacDonald, Instructor in Agriculture, says that in Australia many soils are so poor that they are incapable of producing a remunerative crop. By planting with cowpeas, which are ploughed in immediately they start to bloom, these soils can be regenerated. The soil is broken up, and the organic matters ploughed in decompose, and thus set free the fertilizing elements contained in the soils. In one ton of green manure could be reckoned 1·35 kilos of nitrogen, 0·5 kilos of phosphoric acid, and 1·5 kilos of potash. With an average crop of 14 tons these figures mean a contribution of 40 kilos of nitrogen, 15 kilos of phosphoric acid, and 45 kilos of potash, which is equivalent to 200 kilos of ammonium sulphate, 87·5 kilos of superphosphate, and 85 kilos of sulphate of potash per acre, and this is obviously without taking into account the organic matters which play such an important part.

In Mauritius, according as the cowpea is employed as a mixed crop with canes or as a pure crop, so do the results differ as regards the yield. It is usually ploughed in green, and soils treated in this way are greatly improved. The following figures were obtained from trials between the rows at the Agronomic Station:—

Grey	3,950	kilos, every second row
Brown	4,000	,, ,, ,,
White	3,720	,, ,, ,,
Black	3,260	,, ,, ,,

FIG. 37.—Cowpeas (*Poona* variety) grown in sandy soil at Hawkesbury College (Australia). Yield about 34,600 kilos per hectare.

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FIG. 38.—Cowpeas (black variety). Same conditions as above. Yield about 35,100 kilos per hectare.

Samples taken from the various lots gave the results tabulated herewith :—

PERCENTAGE COMPOSITION OF THE GREEN FODDER.

	Grey cow peas	Brown cow peas	White cow peas	Black cow peas
Water	84·10	86·50	84·30	88·60
Ash	1·40	1·52	1·40	1·02
Cellulose	5·61	3·53	5·29	4·36
Fat	0·67	0·71	0·71	0·28
Sugars	0·98	1·53	—	—
Non-nitrogenous matter	4·94	4·21	5·92	4·12
Nitrogenous matter ...	2·30	2·00	2·38	1·62
	100·00	100·00	100·00	100·00
Nitrogen	0·37	0·32	0·38	0·26

PERCENTAGE COMPOSITION OF THE DRY MATTER.

	Grey cow peas	Brown cow peas	White cow peas	Black cow peas
Ash	8·80	11·30	8·80	8·98
Cellulose	35·31	26·16	33·71	38·30
Fat	4·24	5·23	4·57	2·46
Sugars	6·20	11·33	—	—
Non-nitrogenous matter	31·00	31·17	37·67	36·08
Nitrogenous matter ...	14·45	14·81	15·25	14·18
	100·00	100·00	100·00	100·00
Nitrogen	2·31	2·37	2·44	2·27

PERCENTAGE COMPOSITION OF ASH.

	Grey cow peas	Brown cow peas	White cow peas	Black cow peas
Silica	4·92	4·26	5·91	5·64
Chlorine	3·04	2·88	3·14	2·84
Sulphuric acid ...	3·56	3·39	3·61	[illegible]
Phosphoric acid ...	5·47	6·43	6·55	[illegible]
Lime	24·64	22·10	23·31	29·16
Magnesia	8·10	11·29	10·44	10·23
Potash	25·55	28·40	24·02	22·28
Soda	2·64	1·09	2·85	0·70
Oxide of iron ...	1·48	1·61	1·67	1·32
Carbonic acid, &c. ...	20·60	16·55	18·47	20·44
	100·00	100·00	100·00	100·00

PERCENTAGE OF MINERAL MATTER IN GREEN FODDER.

	Grey cow peas	Brown cow peas	White cow peas	Black cow peas
Silica	0·069	0·065	0·083	0·058
Chlorine	0·043	0·044	0·044	0·029
Sulphuric acid ...	0·050	0·052	0·051	0·029
Phosphoric acid ...	0·076	0·098	0·092	0·047
Lime	0·345	0·336	0·327	0·296
Magnesia	0·113	0·172	0·146	0·104
Potash	0·358	0·432	0·336	0·223
Soda	0·037	0·016	0·040	0·007
Oxide of iron ...	0·021	0·024	0·023	0·013
Carbonic acid, &c. ...	0·288	0·281	0·258	0·214
	1·400	1·520	1·400	1·020

PERCENTAGE OF MINERAL MATTER IN DRY SUBSTANCE.

	Grey cow peas	Brown cow peas	White cow peas	Black cow peas
Silica	0·433	0·481	0·520	0·506
Chlorine	0·268	0·325	0·276	0·255
Sulphuric acid	0·313	0·383	0·318	0·255
Phosphoric acid	0·481	0·727	0·576	0·418
Lime	2·168	2·497	2·054	2·610
Magnesia	0·713	1·276	0·919	0·919
Potash	2·248	3·209	2·114	2·001
Soda	0·232	0·123	0·251	0·063
Oxide of iron	0·130	0·182	0·147	0·119
Carbonic acid, &c.	1·814	2·097	1·625	1·834
	8·800	11·300	8·800	8·980

COMPOSITION OF THE WHOLE CROP.

	Grey cow peas	Brown cow peas	White cow peas	Black cow peas
Silica	2·719	2·600	3·088	1·891
Chlorine	1·683	1·760	1·637	0·945
Sulphuric acid	1·966	2·080	1·897	0·945
Phosphoric acid	3·021	3·920	3·422	1·532
Lime	13·615	13·440	12·164	9·650
Magnesia	4·477	6·880	5·431	3·390
Potash	14·117	17·280	12,499	7·270
Soda	1·456	0·640	1·488	0·228
Oxide of iron	0·816	0·960	0·856	0·424
Carbonic acid, &c.	11·390	11·240	9·598	6·975
Total mineral matter	55·260	60·800	52·080	33·250
Nitrogen	14·500	12·800	14·140	8·470
Weight of green crop	3,950	4,000	3,720	3,260 kilos
" dry crop	628	540	584	372 "

When a seed crop is taken the leaves and stems remaining on the fields still represent a fairly high contribution of fertilizing matters and organic substances.

	Grey kilos	White kilos	Black kilos
Total mineral matter	42·864	44·720	28·690
Nitrogen	7·07	9·10	6·16
Phosphoric acid	1·322	1·976	1·109
Lime	11·56	9·98	6·33
Magnesia	4·01	4·55	2·76
Potash	8·23	12·61	6·68

These figures show clearly the advantage there is to be gained by using this restorative plant, even if the actual object be a seed crop.

We cannot close this account without giving the analysis of cow peas imported into India, published by Dr. Leather in the *Agricultural Ledger*.

FIG. 39.—Disc Harrow preparing a Field of Cowpeas for ploughing under. (Australia.)

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FIG. 40.—Ploughing under a Crop of Cowpeas. (Australia.)

	Seed	
Water	8·85	per cent.
Ash...	3·79	,,
Cellulose	3·20	,,
Fat	1·38	,,
Non-nitrogenous matter	64·31	,,
Nitrogenous matter	18·47	,,
	100·00	
Nitrogen	3·20	,,
Protein nitrogen	2·95	,,

We append further the results of trials made with cow peas in Australia and elsewhere. The following yields per hectare of green fodder and hay were obtained from a pure crop :—

Varieties	Green fodder tons	Hay tons
1	26·654	7·3
2	25·250	6·2
3	24·521	5·9
4	21·323	5·4
5	19·596	5·7
6	18·480	5·2
7	18·480	5·0
8	17·769	4·7
9	16·111	4·3

The above varieties, cultivated in Tennessee, U.S.A., were sown on May 3rd and harvested in August.

In Australia the black variety has been proved to be the most useful. It gives a high yield of seeds, leaves, and stems, and is very well adapted for use as green manure, hay, or seed. Owing to the ease with which the seeds of this variety ripen, it is to be particularly recommended for this last purpose.

The above conclusions are the outcome of various experiments.

M. Desruisseaux informs us of the existence at Anjouan (Comoro Islands) of a wild cowpea which has smaller leaves than the cultivated species. The flowers are pale blue, but there is a pink variety; the stems run along the soil, but are little branched; the seeds are brown, with black stains about 3 mm. across.

An analysis we have made of a sample, for which we are indebted to M. Desruisseaux, gave figures pointing to a richer nitrogen content :—

	In 100 parts of dry matter	In 100 parts of natural substance
Water	— ...	85·15
Ash	15·04 ...	2·23
Nitrogen	3·43 ...	0·51

CHAPTER IV.

COMPARISON BETWEEN VARIOUS ROTATION PEAS.

JUDGING from the results obtained from our experimental fields, it is difficult to say to which pea the preference should be given.

Although, viewed as a whole, all show an equal number of good qualities, yet each individually shows some particular property which may give it the preference according to the conditions under which one is working and the type of cultivation it is wished to pursue.

In fields entirely under a rotation the Lima bean, Bengal bean, and trailing cowpeas will be seen to give excellent results; on the other hand, in a mixed cultivation the jack bean, dwarf cowpeas, and ambériques will give the greatest advantages.

At the same time it should be stated that these latter varieties are just as well suited to be cultivated alone as the former, whose trailing stems prevent their use with canes.

It was interesting to ascertain what influence the distance at which the plants were placed had on the proportional yield of these peas, and with this object some plots were planted at intervals of 0·66 metre, and others at intervals of 1 metre. In the majority of cases the yields of green matter were higher, both when the plants were spaced at intervals of 0·66 metre and when planted singly instead of in pairs.

However, it should be added that in practice it is necessary to sow two or three seeds in a group in order to be sure of a crop. All the plants may be left, especially when the object is to obtain a thick covering to prevent the growth of weeds.

In the following table the yields per hectare of green

fodder are for a pure cultivation, consequently no comparison can be made with those from a mixed cultivation :—

	Lots Planted at 0·66-Metre Intervals		Lots Planted at 1-Metre Intervals	
	1 plant Kilos	2 plants Kilos	1 plant Kilos	2 plants Kilos
Yellow cowpeas	63,950	60,400	53,300	43,350
Grey ,,	74,650	74,650	43,350	32,000
Jack bean...	37,200	32,700	28,450	24,900
Mucuna utilis, black	53,800	47,850	48,500	34,350
,, white	50,450	44,050	30,800	27,000
,, striped	36,250	31,500	43,350	40,300
Phaseolus helvolus ...	55,900	51,650	41,450	39,100
*d'Achery pea	31,500	26,050	23,200	20,750
*Pois dragées	24,150	18,950	20,375	15,850

* Another name for the Lima bean is the d'Achery pea. Pois dragée is the name given in Bourbon to the white variety of this species, which is edible.

The advantage of sowing Leguminosæ in mixed cultivations, that is to say, in cultivations between rows of canes, soon after the latter have been planted, is that they occupy soil which is temporarily empty. They prevent the growth of weeds and retain the soluble salts which, at this period of torrential rains, would be washed away and lost. If the crop is ploughed under when in bloom all these principles are returned to the soil.

If the field is to remain under a rotation crop for a certain length of time, trailing peas are the most suitable, and in the foregoing table we have given the yields that may be expected. In cultivations between canes the yields are considerably lower, as only alternate rows are planted. In that case, either non-trailing peas should be used or the creeping stems should be trimmed off along the whole row to avoid smothering the young canes. Appended are the yields obtained from our trials at the Station :—

CULTIVATION BETWEEN CANES.

Jack bean	14,810 kilos per hectare, green matter
d'Achery pea	11,850 ,, ,, ,,
Crotalaria	11,700 ,, ,, ,,
Phaseolus helvolus	7,050 ,, ,, ,,
Dolichos lablab	11,550 ,, ,, ,,
Ground-nuts	12,600 ,, ,, ,,
Cowpeas ...	10,210 ,, ,, ,,
Voandzeia	9,950 ,, ,, ,,

What is the value of these peas from the point of view of the fixation of atmospheric nitrogen? It is impossible to attribute a greater value to any particular one more than another; the conditions vary with every variety, and numerous other factors enter into play and are the cause of the same pea giving different results.

It is observed that the proportion of nitrogen is higher in some than in others, but when this element is stated in terms of similar areas, provided the yields from these areas are not considerably lower (such as those of the Lima bean and pois dragées), the weights of nitrogen per hectare do not vary within very wide limits.

In the following table we have taken the average of the figures from the four trials quoted in the first table as representing the average yield per arpent, and have calculated the nitrogen per hectare on this basis.

	Nitrogenous matter				
	In 100 parts of dry matter	In 100 parts of green matter	Nitrogen in 100 parts of natural substance	Average yield per hectare in kilos	Nitrogen per hectare in kilos
Yellow cowpeas	21·00	2·40	0·38	55,200	209·7
Grey „	18·93	2·70	0·43	56,150	241·4
Jack bean	18·75	4·69	0·75	30,800	231·0
Mucuna utilis, black	18·12	3·13	0·50	46,200	231·0
„ white	20·06	3·37	0·54	38,150	205·9
„ striped	24·37	4·50	0·72	37,900	272·9
Phaseolus helvolus	17·30	3·32	0·53	46,900	248·5
Lima bean	13·93	2·25	0·36	25,350	91·2
Pois dragées	19·49	2·38	0·38	19,900	75·6

Without drawing any comparisons between these different peas it can, nevertheless, be seen that by ploughing in the crop the total of nitrogen incorporated with the soil is very high and constitutes a clear gain, since the larger portion is derived from the atmosphere. Thus considerable advantage is to be derived from the practice of crop rotation, and no planter who is mindful of his interests should neglect an opportunity of enriching his land every year by cultivating suitable peas, either as a pure crop or interplanted with canes.

Account should also be taken of the sum of organic matters contained in a crop of peas when in flower; organic matters manufactured by the plant itself which break up and enrich the soil.

In the following table we have inserted the weight of organic matter per hectare for each variety, and we are thereby able to calculate the quantity of manure to which this mass of organic matter is equivalent. The first eight varieties give an average of 6,712 kilos to the hectare, equal to about 45 metric tons of manure.

Wherever the soil is impoverished by a mono-culture it is always advisable to return the elements abstracted in a methodical way. In the Coral Islands, where M. Bonâme has made a study of the coco-nut tree, he has not failed in his valuable report on the composition of the coco-nut tree to advise the sowing of d'Achery peas, cow peas, &c. They could be ploughed in and would enrich the soil, which is particularly poor in nitrogen owing to the difficulty with which the leaves and other detritus of coco-nut trees decompose.

	Dry matter per cent.	Green pea per hectare kilos	Dry matter per hectare kilos	Hay per hectare kilos	Organic matter per hectare kilos
Yellow cowpeas ...	11·45	55,200	6,319	6,949	5,558
Grey ,, ...	14·25	56,150	8,000	8,799	7,131
Jack bean	25·00	30,800	7,700	8,470	7,167
Mucuna utilis, black ...	17·30	46,200	7,991	8,790	7,300
,, white ...	16·84	38,150	6,423	7,065	5,859
,, striped...	18·43	37,900	6,984	7,681	6,506
Ambériques	19·80	46,910	9,287	10,216	8,304
Lima bean	16·15	25,350	6,503	7,176	5,873
Pois dragées	12·21	19,900	2,426	2,670	2,189

As analyses of all these crops have been made at the Agronomic Station we have constructed a comparative table showing the proximate analyses of these forage plants. As regards their use in the feeding of live stock we shall study them later. The information will be particularly useful to those who wish to make use of them as green fodder only.

PERCENTAGE OF GREEN MATTER.

	Water	Mineral matter	Cellulose	Fat	Non-nitrogenous matter	Nitrogenous matter	Total
Yellow cowpeas ...	88·55	1·39	3·30	0·37	3·99	2·40	100·00
Grey ,, ...	85·75	1·56	4·04	0·39	5·56	2·70	100·00
Jack bean ...	75·00	2·52	6·12	0·79	10·88	4·69	100·00
Mucuna utilis, black	82·70	1·51	7·19	0·39	5·08	3·13	100·00
,, white	83·16	1·49	6·72	0·54	4·72	3·37	100·00
,, striped	81·57	1·28	7·12	0·70	4·83	4·50	100·00
Ambériques ...	80·20	2·11	7·67	0·66	6·04	3·32	100·00
Lima bean ...	83·85	1·58	6·29	0·41	5·62	2·25	100·00
Pois dragées ...	87·79	1·22	4·27	0·30	4·04	2·38	100·00

It is interesting to see that the species which contains the least water and the highest proportion of ash is the Jack bean; notwithstanding, in the case with which we are dealing the total of mineral matters which it yields per hectare is lower than that of cow peas and ambériques. On analysis the Jack bean gives higher figures for lime and phosphoric acid. These differences in no way imply the superiority of any particular bean.

PERCENTAGE OF DRY MATTER.

	Ash	Cellulose	Fat	Non-nitrogenous matter	Nitrogenous matter	Total
Yellow cowpeas ...	12·02	28·51	3·22	35·46	20·79	100·00
Grey ,, ...	10·87	28·10	2·70	39·59	18·74	100·00
Jack bean	10·01	24·22	3·15	44·06	18·56	100·00
Mucuna utilis, black	8·66	41·25	2·23	29·92	17·94	100·00
,, white...	8·80	39·54	3·19	28·61	19·86	100·00
,, striped...	6·87	38·30	3·76	26·94	24·13	100·00
Ambériques ...	10·58	38·40	3·28	30·58	17·16	100·00
Lima bean ...	9·70	38·56	2·48	35·47	13·79	100·00
Pois dragées ...	9·90	34·67	2·45	33·68	19·30	100·00

It is impossible to decide from these results whether any one pea is more valuable than another. The choice will depend entirely on the type of cultivation intended and the climatic conditions prevailing in the district where it is grown. One pea may be best adapted to these conditions whilst another may be better suited by a different climate. The planter must gain his own experience and decide for himself which variety will be most remunerative.

CHAPTER V.

MANGANESE IN THE LEGUMINOSÆ.

NEARLY all soils contain manganese, and as the majority of plants contain it as well, it is logical to suppose that in many cases this element is assimilable.

It is, indeed, difficult to specify in what forms manganese is found in soils, for while some only give up this element under the action of strong acids, others yield it when treated not only with very weak acid solutions, but even with water.

Having had occasion, since 1897, to pay particular attention to the soils of Mauritius, we have had perforce to inquire into the manganese which a good number contained. The average proportions of manganese in soils are from 0·150 to 0·200 per cent.:—

Localities	Soils	Manganese per cent.
I	1	0·112
	2	0·387
II	3	0·055
	4	0·239
	5	0·233
III	6	0·160
	7	0·211
IV	8	0·214
	9	0·265
V	10	0·180
	11	0·218
	12	0·118
	13	0·108
	14	0·176
VI	15	0·163
	16	0·074
VII	17	0·322
	18	0·179

In a given locality the relations as regards solubility under the action of weak acids and the initial content of manganese in the soil are inconsistent. By initial content is meant the figure obtained by treatment with strong acids.

In the nitrification trials, commenced in 1897 and continued by M. Bonâme in 1898 and 1899, it has been demonstrated that the manganese combines with the nitric acid formed whenever bases, such as lime or ammonia, are absent.

It may be said, without contradiction, that the nitric acid formed during nitrification does combine with the manganese, in spite of the soil not being devoid of lime, and this would prove that the manganese is easily attacked.

The experiments we have made on the solubility of the manganese in our soils in very weak acid solutions have shown this solubility to be fairly great.

Take 100 grm. of dried soil and 500 c.c. of nitric acid solution at 2 c.c. per 1,000.

After dissolving for twenty-four hours, with frequent shakings during the first ten hours, we have:—

IN 100 PARTS OF SOIL.

Total manganese	Manganese soluble in 2 per 1,000	Manganese soluble in water
0·200	0·0161	Traces
0·218	0·0075	,,
0·189	0·0013	,,
0·233	0·0184	—
0·193	0·0008	—
0·265	0·0102	Traces
0·239	Traces	—
0·112	0·0024	Traces
0·387	0·0047	,,
0·118	0·0063	—
0·108	0·0035	Traces
0·322	0·0097	,,

Aqueous solutions were substituted for weak acids, under the same conditions, *i.e.*, 100 grm. of soil + 500 c.c. of distilled water, dissolved for twenty-four hours.

The quantities found were too small to be measured, but the solutions were sufficiently coloured to demonstrate the presence of manganese.

In his annual report for 1908 M. Bonâme has given a series of figures showing the proportions of manganese in the ash of different plants. We reproduce these herewith, at the same time establishing the relationship between the

ash from the dry matter and that from the natural substance in order to demonstrate any differences that may occur.

	In 100 parts of ash	In 100 parts of dry matter	In 100 parts of natural substance
Maranta arundinacea ...	1·155	0·087	0·012
„ dried leaves ...	0·504	0·044	0·010
Thea sinensis ...	0·898	—	—
Rice (stems) ...	0·113	0·014	0·005
Ipomœa batatas ...	0·245	0·030	0·003
Musa paradisiaca ...	0·376	0·033	0·006
Vanilla ...	0·380	0·036	0·004
„ ...	0·680	0·065	0·009
Canes (stems) ...	0·371	0·007	0·002
„ (leaves)...	0·174	0·013	0·003

Notwithstanding that all these plants belong to different families they have all a more or less high manganese content. Some, such as *Maranta arundinacea* and *Thea sinensis*, absorb a fairly high proportion; in the first case we obtain 1·155 in 100 per cent. of ash, and in the second case 0·898.

We have investigated the proportions of manganese contained in the ash of our restorative crops, and have obtained the following results:—

Percentage of manganese, stems and leaves	Ash	Dry matter	Natural substance
Vigna Catjang ...	0·500	0·043	0·009
Lathyrus (Dholl) ...	0·180	0·011	0·010
Voandzeia subterranea ...	0·553	0·053	0·015
Phaseolus lunatus ...	0·341	0·025	0·005
„ *helvolus* ...	0·380	0·028	0·006
Mucuna atropurpurea ...	0·197	—	—
Arachis hypogæa ...	0·205	0·023	0·005
„ „ ...	0·330	0·030	0·007
Cæsalpinia sappan ...	0·174	0·014	0·004
Crotolaria retusa ...	0·090	0·008	0·003
Dolichos bulbosus ...	0·282	—	—
Canavalia ensiformis ...	0.090	0·009	0·003
Tephrosia candida ...	0·090	0·013	0·003

The above results and those from the preceding tables clearly show that the manganese in our soils is readily transferred to the vegetation, and although it is impossible to pronounce as to the usefulness of employing salts of manganese, we may take it that their influence would not have a marked effect on the vegetation.

We have examined the seeds of our leguminous plants to find out whether they contain any manganese, and

although the quantities have not been measured, the following notes will serve to show their content of this element :—

Mucuna utilis	Traces
Cicer arietinum	"
Soja hispida	"
Vigna Catjang	Appreciable
Phaseolus helvolus	"
Canavalia ensiformis	"
Dolichos bulbosus	"
Arachis hypogæa	Traces
Voandzeia	Appreciable
Tephrosia candida	Traces
Psophocarpus tetragonolobus	Appreciable

It seems to be absent from the husks, as the majority of our experiments have given negative results. This element no doubt becomes localized in the seed while this latter is maturing.

According to the experiments already quoted the manganese is seen to be dissolved by water and by very weak acid solutions, and this occurs in soils from various localities. Consequently we may conclude that the manganese in our soils is easily assimilable, because, firstly, water and very weak acid solutions are able to abstract it; and secondly, because plants assimilate it naturally, their ash often containing fairly high proportions. It is difficult to specify the states in which manganese is present in soils, as these states are capable of being modified and the metal transformed into soluble or insoluble salts. In certain soils it is possible that the acids formed during the decomposition of organic matters dissolve certain elements, such as manganese, and combine with them.

In the case of soil analyses by treatment with aspartic acid it has been noticed that, in many cases, an appreciable quantity of manganese is liberated. This would tend to prove that as this metal, in some states, is so easily attacked by organic acids, no special effort on the part of the plant is required to assimilate it. In such circumstances it may be concluded that this metal has a physiological action on the plant.

CHAPTER VI.

PRUSSIC ACID IN THE LEGUMINOSÆ.

SOME considerable time before the discovery of prussic acid by Scheele, in 1782, it was known that certain plants possessed extremely violent poisonous properties. The work of Berthelot and Gay-Lussac shed new light on this question and stimulated further research.

As far back as the beginning of the nineteenth century it was known that several of our colonial peas were of bitter flavour and had a poisonous action. Cossigny, in his "Moyens d'amélioration des Colonies," tells us of a number of accidents that were recorded due to the consumption of certain peas, which, as they grew older, acquired a bitter taste.

In 1898 the chemist Marcadieu established, by a series of most interesting experiments, that prussic acid was not actually found in the seeds of *Phaseolus lunatus,* but was only formed under certain conditions, as, for instance, after several hours' maceration. When the seeds are plunged into boiling water the analysis shows no trace of prussic acid, the latter thus being produced in the same circumstances as in bitter almonds.

M. Bonâme, Director of the Agronomic Station of Mauritius, was the first to deal with the question. In his report for 1898-99 M. Bonâme made a thorough study of the occurrence of prussic acid in this plant, and established its presence both in seeds and leaves after they had been macerated in water.

Like the bitter almond, the d'Achery pea (*Phaseolus lunatus*) contains a glucoside, amygdalin, discovered by Robiquet and Boutron-Charlard in 1830, which, under the influence of a soluble ferment, emulsin, becomes hydrated

and gives rise to benzoic aldehyde, or essence of bitter almonds, to glucose and to prussic acid. This glucoside also becomes hydrated under the influence of weak acids.

In order to bring about this reaction it is sufficient to pound up the almonds and to moisten them; the contents of the cells react on each other and produce prussic acid, whilst in the whole seeds these two elements remain isolated and inactive. When heated to boiling point the emulsin loses its properties.

M. Bonâme has shown that the d'Achery pea behaves in exactly the same way. Pounded up and distilled immediately afterwards, without previous maceration, no trace of prussic acid is found; when macerated for six hours in water this acid is formed and is found in the subsequent distillation. A negative result is obtained if boiling is carried out before maceration.

Thus, under normal conditions, the d'Achery pea contains no prussic acid, and it is only after maceration in water that this acid is formed; lukewarm water accelerates its formation. It has also been shown that the ripe seeds contain a larger amount and that other varieties of the d'Achery pea are absolutely devoid of glucoside.

After M. Bonâme had published his work he was asked by Professor Dunstan to forward some seeds of the d'Achery pea to enable him to investigate the composition of the glucoside which gives rise to the prussic acid.

Professor Dunstan calls it phaseolunatin, and proves that this glucoside is of different composition to that of amygdalin, lotusin, &c. He thinks that the ferment which converts this glucoside into prussic acid is in all probability emulsin.

Since then Dr. Melchior Treub, of Buitenzorg, has made a very complete study of plants containing prussic acid and of *Phaseolus lunatus* in particular.

His investigations have been particularly directed towards the leaves in their various states of growth, and he comes to the conclusion that the proportion of prussic acid is very

much higher in the young leaves and that it disappears as the leaf ages and withers.

Very young leaves	... ...	0·232 per cent.
Leaves on the point of falling...	... ...	0·009 ,,

There is, however, one exception to this rule, and it occurs among the Leguminosæ. The species in question is *Indigofera galegoides,* and it gives the following results:—

Very young leaves	... ...	0·114 per cent.
Young leaves	... ...	0·115 ,,
Adult ,,	... ...	0·145 ,,
Yellow ,,	... ...	0·104 ,,
Fallen ,,	... ...	0·108 ,,

One phenomenon observed by M. Treub is that the leaves of *Phaseolus lunatus* yield prussic acid when distilled direct, that is, without previous maceration.

PERCENTAGE OF PRUSSIC ACID IN FRESH LEAVES.

	Direct distillation	Distillation after maceration	Totals
Water	0·040 ...	0·094 ...	0·134
Absolute alcohol ...	0·003 ...	0·093 ...	0·096
Water	0·105 ...	0·118 ...	0·223
Absolute alcohol ...	0·003 ...	0·191 ...	0·194

M. Treub draws the following conclusions from these experiments: "Undoubtedly a portion of the prussic acid set free in direct distillations is due to a dissolution of glucosides. No matter how rapid be the means adopted for raising the temperature of the leaves to that of the boiling point of water there still remains sufficient time for the enzymes to bring about a certain reduction of the cyanhydric glucosides. On this point a comparison of the mixture, after direct distillation by means of boiling water, with that obtained from a boiling sea-water solution, can leave no doubt."

PERCENTAGE OF PRUSSIC ACID IN FRESH LEAVES.

	Boiling water	Boiling salt water solution
Phaseolus lunatus	0·0'0 ...	0·026
,, ,, ...	0·052 ...	0·029

The differences which exist between direct distillations and those after maceration allow us to suppose that the

prussic acid which occurs does not arise from a glucosidic substance, reduced by an enzyme, but from a much less stable combination. This is the conclusion reached by Dr. Treub. "Besides, other experiments have demonstrated that the reduction of the cyanhydric glucosides in the leaves may be effected with remarkable rapidity. In direct distillations, if cold water be poured over the leaves and these be immediately heated, the quantity of prussic acid set free is much larger than if boiling water had been used at the start. Occasionally the distillation even draws out the whole."

Dr. Treub has carried his investigations still further and has studied the formation of prussic acid, or rather of cyanhydric glucoside, in plants.

His researches on *Phaseolus lunatus* have furnished a proof that the presence of a carbohydrate, and particularly of dextrose, constitutes one of the indispensable conditions of cyanogenesis in the leaves. Thus light merely acts as an agent in the production of carbohydrates, which, in their turn, are necessary for the formation of prussic acid. Cells which normally produce prussic acid are equally capable of forming it in darkness, provided the supply of carbohydrates is sufficient.

One method of proving this was that of enveloping with thin sheets of tin, either portions of young leaves (*Pangium*), or the whole of the young leaves (*Phaseolus*). In spite of etiolation, the foliaceous portions developed under these conditions produced just as much prussic acid as normal leaves.

The researches we have quoted above are of considerable interest and should prove of great assistance in the study of Leguminosæ containing prussic acid. At the same time they are not the only ones which have been published on this question. M. L. Guignard has devoted considerable attention to plants containing prussic acid; Messrs. Greshoff, Van Romburgh, Henry, &c.; and although these latter researches are more general in character, the importance of the

poisonous properties of certain leguminous plants, such as *Phaseolus lunatus,* has been emphasized.

M. P. Guérin, Professor at the Ecole supérieure de Pharmacie de Paris, has published in the *Revue scientifique* (1907) a very complete treatise on plants containing prussic acid, from which we quote several highly interesting passages.

If, after having taken every possible precaution, and supposing the ferment to be completely destroyed by cooking, we were to eat peas, is there a possibility of a ferment occurring in the alimentary canal which would act on the undecomposed glucoside in the same way as emulsin and occasion a fresh formation of prussic acid?

According to experiments made by M. Guignard, the glucoside phaseolunatin is split up, both in the blood and in the alimentary canal, after the glucoside has passed into the intestine, for neither the gastric nor pancreatic juices occasion the formation of prussic acid. On submitting the glucoside of the bean to the action of a mixture of dried pancreatic and duodenal secretions, M. Guignard has obtained a much more definite result than by working with these two substances separately.

To sum up, boiled Java beans (and the water in which they have been boiled as well), even when the emulsin they contain has been destroyed by heat, still retain their poisonous properties; the ferment necessary for the formation of prussic acid being found in the organism.

However, this state of affairs is not universal, and the results may vary according to the individual; in view, though, of the doubt which subsists, it is wiser to avoid these beans.

Among all the Leguminosæ which contain prussic acid most attention should be directed towards the Java bean, or d'Achery pea (*Phaseolus lunatus*), on account of the numerous accidents for which it is responsible.

It is remarkable that Indians are able to eat this pea without harm, provided it has been cooked in boiling water.

The proportion of prussic acid in the seeds varies according to the district from which they come; for instance, the prussic acid content in the seeds of *P. lunatus* from the Dutch Indies differed from that in seeds from British India. Beans from the Cape, Madagascar, Lima, and Sieva are very largely used for human consumption and have never been responsible for any accident, notwithstanding the fact that according to some analyses they contain as much as 0·010 gr. per cent. of poisonous principles. This proportion is only exceeded where the plant shows a tendency to revert to the wild state.

Numerous varieties of the Java bean exist which are edible. Several are grown in Réunion and are highly esteemed; the seeds are of various colours and the white pea, known as the *pois dragée*, is generally held to be the best.

Some people have attempted to generalize from the poisonous action that some Leguminosæ, such as *Phaseolus lunatus*, may possess, and have cast suspicion on such excellent peas as *Canavalia ensiformis* (jack bean), and some others as well.

The experiments we have carried out on these peas at the Agronomic Station have always given negative results. It is admitted that there are some which should not be eaten, such as *Phaseolus lunatus*, *Mucuna atropurpurea*, *Dolichos bulbosus*, &c., but the jack bean, square pea (*Psophocarpus tetragonolobus*), and all the peas cultivated in our gardens offer no danger whatever; on the contrary, they make extremely palatable dishes.

However that may be, according to the figures we give below not one of these peas contains any prussic acid.

Canavalia ensiformis	none
Vigna Catjang	,,
Psophocarpus tetragonolobus	,,
Dolichos bulbosus	,,
Mucuna utilis	,,
Phaseolus helvolus	,,
,, *vulgaris*	,,

Investigations have been made of peas which have been pounded up and digested in water.

Origin and colour of the peas	Percentage of Prussic Acid			
	Dunstan and Henry	Guignard	Kohn Abrest	Tatlock and Thomson
JAVA.				
Mixed peas, all colours...	0·038–0·123	0·052–0·012	—	0·027–0·137
Black	0·107	0·046	—	0·042
Purple black	0·116	—	0·052	0·031
Wine red	—	—	0·058	—
Brown red	—	—	0·037	0·038
Chestnut	—	—	0·050	—
Brown with dark spots ...	0·103	—	0·041	0·038
Pale brown with dark spots	0·104	—	0·126	—
Cream	0·105–0·110	0·052	0·037	0·027
Black with white spots ...	0·062	—	0·058	—
MAURITIUS.				
Purplish black ...	0·088	—	—	—
Brown	0·087	—	—	—
Light brown	0·041	—	—	—
BURMA.				
Light brown with purple spots	0·004–0·024	0·011	—	0·0009
Cream	*nil*–0·027	0·006	—	
FRANCE.				
Beans from Lima, cream	*nil*	traces	—	—
,, Sieva ,,	traces	0·004–0·008	—	—
,, the Cape, veined	traces	—	—	—
MADAGASCAR.				
White	—	0·008		—

At the same time it should be remarked that even some edible peas contain very small quantities of prussic acid.

Above is a highly interesting table on the prussic acid content of various peas from Java, Mauritius, Burma, France, and Madagascar. For purposes of comparison analyses made by Dunstan, Guignard, Kohn Abrest, and Tatlock have been tabulated.

A few samples obtained from London merchants and examined at the Imperial Institute have given:—

White peas from Rangoon... ...	0·025 per cent. prussic acid	
,, ,, Burma	0·026 ,, ,,	
,, ,, Lima (America) ...	none	

Other samples from London and Paris of white and black Algerian beans, reddish-black beans and Danube peas have given negative results.

In spite of all these researches and the conclusions to be drawn from them, the fact still remains that these peas form a very useful nutriment and are in very general use. There is consequently ground for believing that these traces of prussic acid are not formed during cooking, and that prolonged boiling causes them to disappear. Not a single case of poisoning has been recorded, although for many years past numerous varieties of beans have been in use, both for human and animal food.

It is therefore easy to believe that only a few rare species are harmful, and it is wrong, merely on account of a rumour, to deprive mankind of the resources offered by nature, especially in new countries.

Some authors seem to attribute the varying proportion of prussic acid in similar varieties to the colour. Judging from our experiments, we are not of this opinion, but it is practically certain that peas improve under cultivation and that the glucoside tends to disappear.

The seeds of *Phaseolus lunatus* (Burma pea), either red or white, now on the market, do not appear to have caused any accidents.

In both these kinds the content of the cyanogenetic element apparently does not exceed an amount equivalent to 0·020 per cent. of prussic acid.

As regards the other varieties, beans from the Cape, Madagascar, Lima, and Sieva, in general use as human food, cultivation has caused a very large portion of the poisonous principle to disappear, the amount usually not exceeding 0·010 per cent. (calculated in prussic acid).

All these peas give excellent results and deserve attention, forming as they do a first-rate nitrogenous food.

DANGEROUS PLANTS.

Prussic acid is not the only danger offered by the Leguminosæ, a danger which, although it has sometimes

been exaggerated to the extent of weaving fables around some of their number, is none the less existent, as witness the cases of poisoning which have been recorded.

A number of other plants belonging to this great family have been the cause of accidents and have been classed as dangerous. Where live stock is concerned it is sometimes difficult to decide that the mortality is due to any poisonous properties the Leguminosæ may possess, because abuse of these plants, as of many others, may provoke a distension of the stomach which is capable of causing death. However, such is not often the case, and it is no cause for astonishment that, in a botanical order containing such varied species, we should find plants of different properties, some nutritious and harmless and others poisonous.

Professor Ralph Stockman, of Glasgow University, maintains that the poisonous properties of certain Leguminosæ are due to the presence of a saponin.

Mr. Maiden, botanist, and Director of the Gardens in Sydney, New South Wales, has contributed a very interesting article on this subject to *The Agricultural Gazette*, from which we will give some extracts.

Mr. Maiden does not give the whole of the observations made as being certain. It is possible that some points have been slightly exaggerated, but it is none the less true that accidents of various kinds have been recorded by responsible persons, and it is as well to draw attention to these facts in order to enlighten others who may be similarly placed.

For our own part we think it useful to give a short note on each of the plants recorded. Those in new countries who wish to devote themselves to farming will find some useful points which should spare them annoyance.

The subject has been treated by a number of writers, and among the chief works of interest we may quote the following:—

Professor Mac Owan.—"References to Leguminous Poisoning and Symptoms resembling it."

H. TRYON.—"Plants Poisonous to Stock."

BAILEY and GORDON.—"Plants reported Poisonous and Injurious."

CORNEVIN.—"Plantes vénéneuses."

J. KENNEDY.—"On Loco-weed (*Astragalus mollissimus*)."

T. WILLIAMS.—"Some Plants Injurious to Stock, &c."

The reports of the Agricultural Departments of the United States, Queensland, the Cape, New South Wales, &c., contain several articles on this question which are of great interest.

PAPILIONACEÆ.

Abrus precatorius (Climbing Shrub).—This plant has small red seeds with black specks commonly called "crab's eyes."

In 1870 the Indian Commission reported that numerous cases of poisoning of live stock caused by the seeds of this leguminous plant had been recorded.

Astragalus (Under-shrub).—This genus is accused in the United States of being responsible for *loco disease*. The species *mollissimus* is reputed to be most dangerous, and *Astragalus lentiginosus* and *Hornii* are also injurious.

Anagyris fœtida (Shrub).—This is a shrub of which every portion is poisonous, but it offers little danger owing to its rank smell, which deters animals from browsing it. The poisonous seeds have sometimes been mistaken for those of the bean owing to their resemblance to these latter.

Brachysema undulatum (Shrub).—According to F. Turner this plant is considered poisonous in Western Australia.

Canavalia obtusifolia (Liane). A dangerous plant which is encountered in all tropical countries.

Crotalaria alata (Shrub).—An Indian plant which, according to a report of the Queensland Agricultural Department (1891), is poisonous to live stock in that country.

Crotalaria sagittalis (Shrub).—This *Crotalaria* is one of the *loco weeds* of U.S.A. In *Bulletin* No. 33, A. Williams attaches such importance to the injurious properties of this plant that he applies the name of *crotalism* to a disease in horses which feed upon it. It seems to be the same as *loco disease* and *indigo disease*.

Although this plant is reputed to be very dangerous in New South Wales and Queensland, in India, where it is very widely distributed, it does not appear to have any harmful effect on cattle.

Crotalaria Mitchellii (Shrub).—This species occurs in the southern part of Australia, New South Wales and Queensland, and is suspected of being poisonous.

Cytisus (Shrub).—The plants of this genus are very dangerous on account of the alkaloid, *cytisin*, which they contain. Every portion of the plant is poisonous, wood, bark, leaves, floral buds, flowers, pods, seeds, and also the subterranean portions.

Man as well as beasts are susceptible to this poison. It is the flowers which are the cause of accidents among human beings.

Ervum ervilia (Herb).—This plant is cultivated in Algeria and other localities and the seeds are used for feeding live stock. It should not be used alone, nor should a diet of this leguminous plant be too prolonged, as it contains an injurious element. Animals are more or less susceptible to it, and, according to M. Cornevin, the effects are not uniform. The following animals may be said to be most susceptible: poultry, pigs, horses, mules, sheep, and oxen.

The chief symptoms are somnolence passing into a state of coma, interrupted from time to time by muscular seizures, and sometimes by nausea and vomiting.

Castrolobium (Shrub).—The following species are commonly known as "Poison bushes": *Gastrolobium obovatum*, *G. trilobum*, *G. spinosum*, *G. oxylobioides*, *G. calycinum*, *G. callistachys*, *G. bilobum*.

According to Hooker's "Journal of Botany" the strongest animals are the first to fall victims. The first sign is a difficulty in breathing, which lasts for several minutes; they then begin to stagger, and eventually fall and die. After death the stomach of the animal turns brown: apparently the poison enters the blood-stream and completely arrests the action of the heart and lungs. The dead flesh of such animals poisons cats, and the blood, which turns very black, is fatal to dogs. However, the natives are able to eat the flesh, either roast or boiled, without feeling any ill-effects whatsoever.

The flowers are the most poisonous portion of the plant and cause the death of numbers of sheep. Apparently horses are exempt. The same book adds that the best remedy for the sheep is to pen them up in a fold in such a way that they are unable to move, and to keep them in this position for thirty-six hours.

Castrolobium bilobum (Shrub) is known as the "Heart leaf poison bush." It has been studied by Fraas and Wolff. In the "Flora Australiensis" it is said to be the most redoubtable of the bush poisons.

Castrolobium calycinum (Shrub).—In Western Australia this variety is called "York Road poison," and *G. callistachys* is called "Rock poison." They have been studied by Professor Stockman.

Castrolobium grandiflorum (Shrub).—Baron Mueller recognized that numbers of sheep and cattle had been poisoned by this plant in Queensland. In order to be rid of it he advised setting fire to it wherever it occurred. It is known in Queensland as "Wall flower" or "Desert poison bush."

Compholobium uncinatum (Shrub).—In "The Treasury of Botany" this plant is considered to be very dangerous to sheep.

According to Hooker's "Journal of Botany" an experiment with this plant on sheep led to the rapid death of the animals. However, Mr. H. Maiden, Government Botanist in Sydney, states that in Australia the plants belonging to the genus *Gompholobium* are harmless.

Goodia (Shrub).—Two species are found: *G. latifolia* and *G. medicaginea*. They are shrubs of fair size, the former in favourable circumstances even attaining the dimensions of a small tree; the flowers are yellow.

Goodia latifolia has poisonous foliage. Shepherds state that flocks display a relish for them which leads to their own undoing. In sheep which have eaten them the tongues turn black, the skin takes on a bluish tinge and becomes stiff, and the animals weaken and die.

There is some disagreement as to the poisonous properties of these plants. Some say they contain no poison, but if eaten to excess may cause death through dilatation of the stomach or through stoppage of the intestine owing to inability to digest the fibrous branchlets.

Cymnocladus dioica (Tree.)—This is a North American tree. In America the seeds are called "coffee-beans," and when roasted are sometimes used as a substitute for coffee.

These seeds are poisonous, and influence the motor nervous system by causing the voluntary muscles to work spasmodically.

Saponin has been extracted from the seeds, and it is supposed that the symptoms observed are due to this glucoside or to the element with which it is intimately connected.

Indigofera australis (Shrub).—This plant is under suspicion and is considered as dangerous. It is stated that the urine of cattle which have eaten it is red in colour. Would this be due to hæmatein, or to the presence of a pigment from the plant?

Isotropis juncea (Herb).—According to Turner this plant is reputed to be poisonous in Western Australia.

Lathyrus sativus (Herb).—This legume, if eaten to excess, often causes paralysis of the lower limbs, which is known as *lathyrism*. This disease occurs in Europe as well as in the Colonies, and not only attacks man, but horses, oxen, and pigs as well.

The seed is the most poisonous portion, but the stems, leaves, and empty pods are also injurious. Desiccation has no influence on the poisonous properties.

This legume has always been considered as dangerous. We have records from the remotest times of accidents to mankind.. Columella and Pliny among the ancients; Olivier de Serres (1691), Duvernoy (1770), among the moderns; and of recent date Vilmorin, Yvart and a number of doctors have designated it as dangerous. Dr. Koschnevikoff, Professor of Pathology at the University of Moscow, has written a most interesting article on lathyrism. In 1891, when the famine deprived the peasants of wheat, they manufactured bread with *Lathyrus sativus*, and this gave rise to the illness in question.

In India, recently, more than 7,600 cases of lathyrism have been reported and proved to be due to the excessive use of *Lathyrus sativus*.

In Australia sheep are attacked with lathyrism after eating a species of *Swainsonia;* at the Cape, goats contract *Nenta,* a kind of lathyrism caused by a leguminous plant of undetermined species; in the United States *loco disease* is caused by Leguminosæ.

Lessertia annularis (Herb).—*Lessertia annularis* appears to be the cause of cerebro-spinal meningitis in goats, and recorded in South Africa under the name of *Thenta.* It is curious to note the analogy which exists between the *loco disease* caused by *Astragalus lentiginosus, the Gompholobium* of Australia, the *Sophora secundiflora* of Texas, and to a lesser degree the *Tagosaste, Cytisus proliferus,* which is injurious to horses.

Lotus australis (Herb).—This plant has been recorded as dangerous in Australia. Baron Mueller speaks of its influence on the brains of sheep, which often has fatal results.

M. Diston, however, assures us that the *Lotus* is an excellent fodder plant and is only injurious when eaten in excessive quantities; there is no objection to its being given to "folded" sheep.

Lupinus (Shrub).—The genus *Lupinus* contains several varieties the seeds of which are poisonous. They have often a bitter flavour and are the cause of mishaps; the disease known as *lupinosis* is particularly prevalent among sheep, but other animals are not exempt, and man can make but little use of the seeds of the lupin.

Poisoning causes violent fever with circulatory and digestive troubles, spasms, &c.

M. Baumert states that the real active principle in the lupin is an alkaloid, which he calls *lupinin,* the formula for which is $C_{21}H_{40}N_2O_2$.

Schulze and Barbieri gave the name of *lupinide* to a non-nitrogenous glucoside which they succeeded in extracting from the lupin.

Mucuna sp. (Trailing Herb).—In Senegal a *Mucuna* of undetermined species is regarded as poisonous by the natives.

Oxylobium parviflorum (Shrub).—Known in Western Australia under the name of "Box poison," and recorded by Bentham as one of the most poisonous plants. The species *O. retusum* is called "Bloom poison."

Oxytropis Lamberti (Undershrub).—In the United States this plant is the cause of a *loco disease* very similar to that provoked by the genus Astragalus.

Phaseolus vulgaris (Undershrub).—Numerous observations have established the fact that neither horses, pigs, dogs, cats, rabbits, guinea-pigs, nor poultry eat the pods or seeds of the bean, either raw or cooked.

M. Cornevin has endeavoured to ascertain whether these plants contain a poisonous element which has no action on the organism, and

has concluded that they do. His results, which are purely scientific, in no way detract from the great value of this nutriment.

Piscidia erythrina (Tree).—The bark is used to poison streams.

Sabinea florida (Shrub).—According to Schemburg, the buds are poisonous.

Sophora secundiflora (Shrub).—This leguminous plant is said in Mexico to occasion tetanus in animals which feed on the leaves or seeds. The seeds contain a highly poisonous alkaloid, *sophorin*.

Sophora tomentosa (Shrub).—This variety also contains the poisonous alkaloid in its seeds, but does not appear to have any dangerous influence. It is given to animals in Madagascar.

Swainsonia Greyana (Shrub).—Some observers say that this plant is dangerous and causes madness in horses, others again say that it may be eaten without detriment. It is found in South Australia, Victoria, New South Wales, and Queensland.

Swainsonia Oliveri (Shrub). This variety and also *S. galegifolia* are both said to be poisonous, and both provoke cerebral troubles.

Templetonia egena (Shrub). According to the *Gardeners' Chronicle*, this legume causes spasms in live stock which lead to paralysis. It is found in Australia. The variety *T. retusa*, from Western and Southern Australia, induces the same symptoms.

Tephrosia purpurea (Shrub).—Bailey and Gordon say this plant is poisonous and is used for stupefying fish, thereby facilitating their capture.

Trifolium (Herbaceous Plants). Some varieties of clover are injurious to live stock. M. Cornevin states that even the Hybrid Clover usually recommended as a fodder plant is not eaten very readily by domestic animals, the horse in particular.

This food has its drawbacks, all the more so as the evil is not entirely overcome by dropping the diet. Intestinal lesions and inflammation of the mouth occur, and a considerable quantity of saliva is rejected.

The general symptoms are very profuse sweats, spasmodic movements of the jaws, and frequently a tumefaction of the face and upper lip.

CÆSALPINIEÆ.

Cassia sp.—Is an undetermined variety from New South Wales, the leaves of which are said to act as a purgative on horses and cattle.

Cassia lævigata (Shrub).—Suspect.

Cassia occidentalis (Shrub). Mr. Bailey (Australia) states that this plant is under suspicion.

Cassia mimosoides (Shrub). Considered as dangerous in Ceylon.

Cassia Sophera (Shrub). Found in South Australia, New South Wales, Queensland, &c., and regarded with suspicion.

Cassia Sturtii (Shrub).—This legume is found throughout Australia, excepting Tasmania, and is suspected of being poisonous.

Detarium sp. (Tree).—In Senegal, where this variety is known as *Detach*, it bears a fruit which is regarded as violently poisonous.

Detarium microcarpum (Tree).—The sap of this member of the *Cæsalpinieæ* enters into the composition of *Korté*, a powerful and active poison used in Senegal and the Soudan. A single pinch thrown among a person's clothes is sufficient to cause serious disorders and even death. This poison is kept in a *fourgou* (skin of monkey, hyæna, or cat) (Constancia).

Erythrophleum (Tree). This tree contains an alkaloid, *erithrophlein*, discovered in 1887 by Messrs. Gallois and Hardy in *E. guineense*.

This alkaloid is a violent poison which is not destroyed by drying or boiling. It has a very violent action on horses and other animals. The *erythrophlein* is found in the bark, leaves and fruits. A decoction of the bark is used by natives of Guinea for poisoning their weapons.

Absorption of the poison causes collapse, nausea, and vomiting, and the action of the heart is paralysed.

Erythrophlein is soluble in water and alcohol, slightly soluble in chloroform and benzine.

The two varieties *E. guineense* and *E. Commingo*, are reputed poisonous.

MIMOSEÆ.

Acacia verniciflua (Shrub). This plant is said to be poisonous in Tasmania. It is widely distributed in Australia.

Albizzia stipulata (Tree). According to Mr. Hartless, the young leaves of this *Albizzia* are injurious to live stock.

Leucæna glauca (Shrub).—May be eaten without harm by oxen, goats, &c. Is extremely injurious to horses and mules. The hairs drop out of tail and mane.

Mimosa pudica (Shrub). In Ceylon the sensitive species is considered to be dangerous to live stock (Macmillan).

Prosopis juliflora (Tree). The fruits are used in the feeding of live stock, but it has been noticed that they may become injurious when the seeds have been moistened by rain. They then germinate in the stomach and cause wind.

CHAPTER VII.

STARCH IN THE LEGUMINOSÆ.

STARCH is found in all plants, and some form reserves, either in their roots, as, for instance, the Yam bean (*Dolichos bulbosus*), or in their seeds, like the cereals.

The seeds of the Leguminosæ, though less rich than those of cereals, nevertheless contain from 30 to 50 per cent. of starch. There are exceptions: several contain high proportions of fat, and others, as will be seen later, contain only a very small amount; however, their proximate compositions differ very slightly.

Starch is a ternary substance belonging to the group of carbohydrates. Its formula corresponds to that of cellulose and dextrine, with a variant in the coefficient representing the molecule ($C_6H_{10}O_5$).

Starch is formed by special corpuscles or plastids. These plastids occur in the protoplasm and are divided into special colourless leucoplasts or amyloplasts, and chloroplasts which constitute the chlorophyllose bodies. In the case of the embryos the general protoplasm itself seems occasionally to secrete starch.

M. Dubard, in his course on "Colonial Applied Botany," explains the formation of starch grains as follows:—

"When the grains appear towards the centre of the parent leucoplast they remain for a very considerable period surrounded by its substance, and growth takes place in an almost uniform manner over the whole of their surface, the result being a grain with a central nucleus. If, on the other hand, the birth of the grain occurs towards the periphery it

soon causes a projection upon the exterior of the leucoplast; it grows considerably more or even entirely upon the side which is immersed in the substance of the leucoplast, and the nucleus becomes eccentric and thrown out to the remote side of the leucite."

What is the mechanism of the growth of the starch grain? According to M. Dubard, it takes place by apposition, that is to say, by the deposition of new layers upon the surface of the grain already formed; there is no imbibition, that is, no intussusception of particles among those already laid down.

"The best proof of the apposition is afforded by observation of the cotyledons of Leguminosæ while the seeds are being formed. Tissue development being very active the reserves begin to be dissolved; the starch grains are worn away, sometimes perforated; then, once the tissues of the embryo have become definitely differentiated the storing-up phase recommences and new layers develop around the corroded grain. Whatever the thickness of these new layers, the original granule, of which the appearance has not varied, can always be detected in the centre of the grain.

Generally all starch grains are characterized by a series of striations and an initial nucleus or hilum.

These striations are refractive differences due to an unequal distribution of water; the bright layers correspond to the regions which are poor in water, the dark layers to the portions which are richest. When first formed the nucleus is a bright point; gradually, as the central portion becomes hydrated, it turns darker, with a bright periphery. This latter growing in its turn the same phenomenon occurs anew.

According to Payen, the density of starch is from 15 to 20. When dried in air at only 20° C. it retains from 18 to 35 per cent. of water. It is only towards a temperature of 140° C. that it becomes completely dehydrated.

Starch is birefractive, a property which is consequent

on its physical constitution, as it is a structure of sphero-crystals. From the optical point of view, starch behaves as if it were formed of small crystals arranged in close radial lines and shining round a centre which is the nucleus or hilum. Such is the explanation given by M. Dubard of the phenomenon of the black cross observed in numerous varieties of starch. Each grain is split up into two dark fields, which intersect at the hilum and which increase in size from the centre to the periphery; the remainder of the grain appears, on the contrary, in full light. This polarization enables the position of the hilum to be determined, although it is not always visible. It is to be noted that some starch grains do not polarize, and even in a given variety some polarize and others do not. This is probably a question of the degree of maturity of the grains.

Amylase and acids both convert starch into glucose.

According to most writers, the morphological characters may be classed under the following headings:—

(*a*) Size of the grains,

(*b*) Shape,

(*c*) Visibility, shape, arrangement of the nucleus and of the striations.

In our experiments on starches it has not been possible for us to give the dimensions of the grains, the characters of these latter being so dissimilar.

Owing to the size of the grains, sometimes varying within very wide limits, the average dimension is a very arbitrary figure and would give absolutely no information as to the exact dimensions of the grains. Neither does the measurement of the extremes, *i.e.*, of the largest and smallest grains, offer any advantage, as one or other of the two may predominate. We have, therefore, been content to sketch them with the aid of the camera lucida, retaining the same eye-piece and objective for all. In this way we get a standard of comparison which enables us to appreciate the different proportions of the grains in the Leguminosæ examined.

The shape of the grain is a valuable index to the identification of starches. It varies considerably from one plant to another, but often retains the same appearance in similar portions of a given variety; whilst it may vary in the root and in the seed of the same plant, if that particular plant contains starch, *e.g.*, *Psophocarpus tetragonolobus*.

The hilum may be punctiform, that is, forming a small circular or elliptical surface, stellate, linear, or branched.

The position of the hilum is sometimes central, sometimes eccentric. The side on which it is situated should be given, either on the small or on the large side.

The striations are for the most part scarcely visible, and are only distinguished through their more or less crowded arrangement and their more or less accentuated curvature. The hilum acts as a centre to the striations, which approach the circular in shape, and the intervals between them vary according to the position of the nucleus.

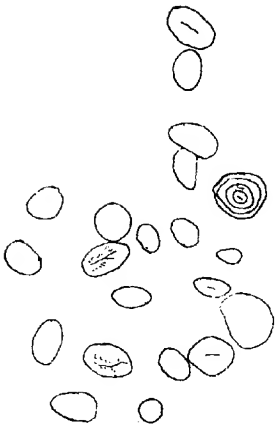
These few details on the method of formation of starch grains and their distinctive characters have been given in order to enable the reader to understand better the examinations which have been made of different peas and other Leguminosæ. They may thus prove useful to any who wish to extend existing researches.

CHARACTERS OF THE PRINCIPAL STARCHES IN THE LEGUMINOSÆ.

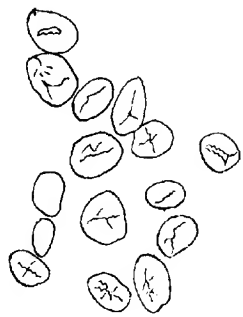
Arachis hypogæa (Pea-nut).—Seeds very poor in starch. The shape of the grains is very uniform, usually round, some are double the size of others. Polarization is only observed in the large grains. The hilum, chiefly visible in the big grains, is stellate, rarely punctiform. Striations invisible. Starch fairly homogeneous.

Cajanus indicus (Pigeon Pea).—Seeds rich in starch. The shape of the grains is fairly uniform, whilst their size is very variable. Polarization is general and well marked. The hilum is linear, very rarely punctiform and more often branched; numerous grains are found in which no hilum can be seen. The striations are only visible in a few rare grains; they are not very close together. Starch only slightly homogeneous.

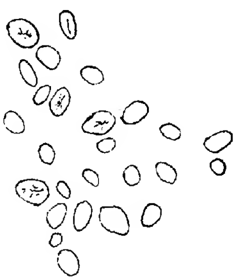
Canavalia ensiformis (Jack Bean).—Seeds rich in starch. The shape of the grains is fairly uniform, whilst their dimensions vary; the



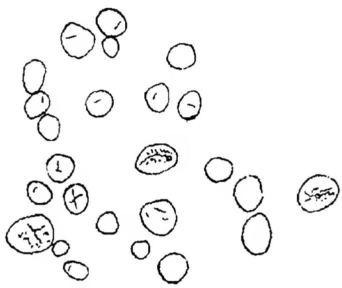
Cajanus indicus (Pigeon Pea).



Phaseolus inamœnus (Pois du Cap).



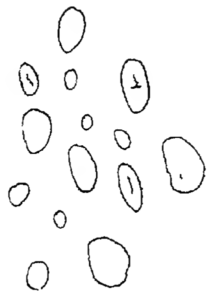
Cicer arietinum (Chick Pea).



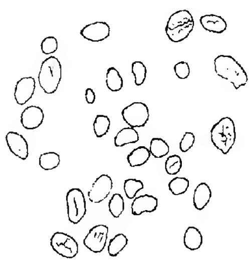
Mucuna utilis (Bengal Bean).

FIG. 41.

Phaseolus lunatus (Lima Bean).



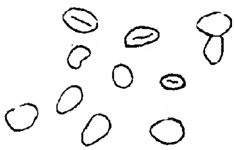
Soja hispida.



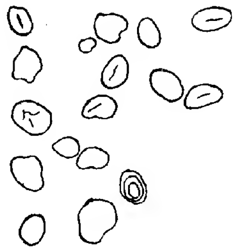
Vigna Catjang.
(Cowpea, black-eyed variety).

Vigna Catjang.
(Grey Cowpea).

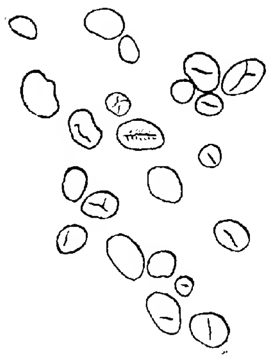
FIG. 42.



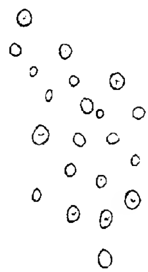
Psophocarpus tetragonolobus (Pois carré, from seeds).



Dolichos Lablab.



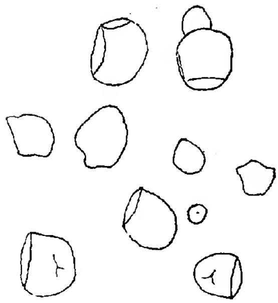
Ervum lens (Lentil).



Arachis hypogæa (Ground-nut).

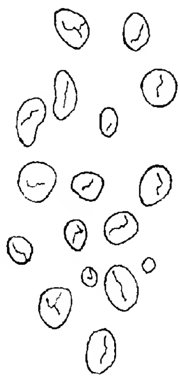
FIG. 43.

Vicia faba (Bean).



Psophocarpus tetragonolobus (Pois carré, from roots).

Phaseolus vulgaris (Haricot Bean, red variety).



Phaseolus vulgaris (Haricot Bean, white variety).

FIG. 44.

medium-sized grains are the most numerous. Polarization is general and well marked. The hilum is very distinct in the grains of large and average size, but is scarcely visible in the small ones; it is linear or curved, and sometimes formed of divergent lines. The striations are invisible. Starch fairly homogeneous.

Cicer arietinum (Chick Pea).—Seeds rich in starch. The shape of the grains is regular and rather ovoid, and they are of practically similar size. Polarization only occurs in the largest grains. The hilum is linear, long and very often branches, and is only visible in a certain number of grains. The striations are hardly visible and very crowded. The starch has a fairly homogeneous appearance.

Dolichos bulbosus (Yam Bean).—Seeds poor in starch. The shape of the grains is regular, generally ovoid, and there is little difference in their dimensions. All the grains polarize distinctly. The hilum is visible in some seeds, not in all; it is linear. Striations invisible. Starch fairly homogeneous.

Dolichos bulbosus (Roots).—The shape of the grains is irregular and the dimensions are very variable. The hilum is punctiform, sometimes linear; but it is usually rather rare. None of the grains polarize. Striations visible. Starch not very homogeneous.

Dolichos Lablab (Bonavis Bean).—Seeds rich in starch. Shape of the grains fairly uniform, size varying but little. All the grains polarize clearly. The hilum, which occurs somewhat rarely, is linear, and occasionally branched. Striations invisible. Starch fairly homogeneous.

Ervum lens (Lentils).—Seeds rich in starch. The shape of the grains is variable; their size extremely so. Polarization occurs generally. The hilum is linear, very conspicuous, and often branched. Striations invisible. Starch not very homogeneous.

Mucuna utilis (Bengal Bean).—Seeds rich in starch. The shape and size of the grains are very variable. Polarization occurs in the majority of the grains, but is rather feeble. The hilum appears to be linear, it assumes, however, numerous shapes and its position varies in different grains. Striations fairly apparent in some of the big grains. Starch not very homogeneous and the small grains predominate.

Phaseolus inamœnus (Pois du Cap).—Seeds rich in starch. The shape of the grains is variable, whilst their size is fairly uniform. All the grains polarize distinctly. The hilum is linear and very frequently branched. The striations are indistinct and scarcely visible. Starch not very homogeneous.

Phaseolus lunatus (Lima Bean).—Size and shape of grains very variable. Polarization is only seen in the large grains. The hilum is linear, but branched in the majority of the grains. Striations only slightly visible and can only half be made out. Some compound grains are found. The grains are not homogeneous in appearance.

Phaseolus helvolus (Ambérique).—Seeds rich in starch. Shape fairly uniform and size rather variable. All the grains polarize distinctly. The hilum is very distinct, it does not appear in a few small grains; it is linear, sometimes curved, very rarely branched. Striations only slightly visible. Starch fairly homogeneous.

Phaseolus vulgaris (Red Variety).—Seeds rich in starch. Shape fairly uniform, and size rather variable. No polarization is observed. The hilum, which is most distinct, is either linear or slightly bent. Striations invisible. Starch fairly homogeneous.

Phaseolus vulgaris (White Variety).—Seeds rich in starch. The shape of the grains is fairly uniform, but they vary more in size than those of the red variety, the large grains predominating. No polarization. The hilum is very distinct, linear, often considerably bent, rarely branched. Striations invisible. Starch only slightly homogeneous.

Psophocarpus tetragonolobus (Pois carré).—Seeds poor in starch. Grains of irregular shape and variable size. The hilum is linear, very conspicuous in some and only slightly visible in others. Starch only slightly homogeneous.

Psophocarpus tetragonolobus (Pois carré; Roots).—Roots rich in starch. The shape of the grains is very variable, but often like that of a bell, and their size is equally variable; the large grains, however, predominating. All the grains polarize. The hilum, which only occurs rather seldom, is stellate and punctiform, rarely linear. Striations invisible. Starch only very slightly homogeneous.

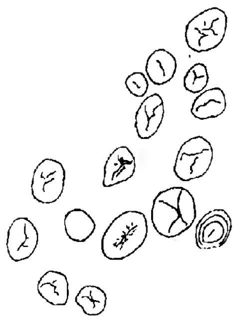
Soja hispida.—Soy contains very little starch. The shape of the grains is fairly uniform, whilst their size is very variable. All the grains polarize clearly. The hilum is linear, occasionally stellate, but of rather rare occurrence. The striations are only visible at the edges and are very close together. Starch only very slightly homogeneous.

Vigna Catjang (Cowpeas, Black-eyed).—Seeds rich in starch. The shape of the grains is very variable, similarly their size. Both the smallest and the largest grains polarize clearly. The hilum is linear, frequently branched, and very irregular in appearance. The striations are not visible, or at least only with difficulty. Starch only very slightly homogeneous.

Vigna Catjang (Grey Cowpeas).—Seeds rich in starch. The shape of the grains appears to be considerably more variable than in the preceding variety, similarly the size. Polarization is general. The hilum is linear and branched, sometimes dividing the grain into two; it is most variable both as regards shape and position. Striations scarcely visible. Starch only slightly homogeneous.

Vicia faba (Bean).—Seeds rich in starch. The shape and size of the grains are very variable; a certain number of very large grains

Canavalia ensiformis
(Jack Bean).



Voandzeia subterranea
(Bambarra Ground-nut).

Phaseolus helvolus
(Ambérique).

Dolichos bulbosus
(Yam Bean).

FIG. 45.

are found, which considerably exceed the average in size. None of the grains polarize. The hilum is rather rare; most frequently linear, rarely branched. Striations invisible. Starch only slightly homogeneous.

Voandzeia subterranea (Bambarra Ground-nut).—Seeds fairly rich in starch. The grains are rather uniform both in shape and size. Polarization is general. The hilum is very variable, rarely linear, very frequently branched and formed by a network of branching lines. Striations very fine, scarcely visible save in a few rare grains. Starch fairly homogeneous.

CHAPTER VIII.

USE OF THE LEGUMINOSÆ FROM AN AGRICULTURAL POINT OF VIEW.

The employment of peas in rotations in colonial agriculture dates back to the beginning of the last century, and was due in Réunion to the initiative of M. Joseph Desbassyns. In a report to the Colonial Minister, dated May 5th, 1816, he gave a detailed account of the system which had been so successful and advised its extension to Bourbon.

M. Desbassyns left a portion of his land under ordinary pigeon peas for four years. The pigeon peas served as supports for the stems of the peas, and he advised cutting them down in the course of their growth in order to give the peas more scope. The good results which M. Desbassyns obtained encouraged the other colonists, and in this way Réunion was foremost in adopting his system.

M. Joseph Desbassyns had studied in France, where he was able to appreciate the value of Leguminosæ in restoring soil fertility, especially with regard to sainfoin (wild) and lucerne. However he realized that this improvement would only be effected so long as tropical plants were utilized. He consequently sowed ordinary peas and pigeon peas without attempting to introduce European species of Leguminosæ. Several years would have been required for these latter to become acclimatized, and even then success might not have been achieved, as we know that lucerne does not thrive in our soils.

It will be seen later that the colonial agriculturist was perfectly right, as our tropical Leguminosæ furnish, in a

shorter period, a mass of green matter, in the shape of fodder or manure, considerably higher than that of any leguminous plant of the temperate zone.

At the same time it should not be supposed that the effect of the Leguminosæ was completely unknown before M. Desbassyns' period, *i.e.*, 1816. Cossigny, in his treatise "Moyens d'amélioration des colonies," published in 1802, relates that the colonists of Teneriffe also sowed a number of plants to enrich the soil and to take the place of manure: the bean, vetch, lentil, and especially lupin, which, according to Columella, produced better results than any other plants. Some agriculturists ploughed their fields after the harvest and so buried the stems, roots and leaves remaining on the surface.

Others, who were wiser, turned over the soil with the plough whilst the plants were still growing, burying them whole. In this way the soil was provided with an excellent manure. They were also sown around sick trees and sickly vines in order to invigorate them. Others again made up a decoction which they spread around fruit trees. This latter method was regarded as particularly efficacious.

The cultivation of Leguminosæ responds to three different needs on the part of the agriculturist, which depend on the varying conditions in different localities. In the colonies where, one may say, no attention is paid to anything but the sugar-cane, the Leguminosæ are only regarded as restorative plants which enrich the soil, where they grow, in organic matter, humus, and nitrogen, and choke the weeds which would overrun the land if peas, cowpeas, or indigos were not grown to check them.

We do not believe that all the advantages that agriculturists, from remotest times, have derived from the cultivation of Leguminosæ reside solely in the fixation of atmospheric nitrogen and the enrichment of the arable layer in this element. And this, notwithstanding the fact that nitrogen is so invaluable for the production of fine crops,

and constitutes in the fertilizer industry the best and highest-priced manure. M. Desbassyns has demonstrated in Réunion the effects of Lima beans on particularly poor soils, the yields having been increased in remarkable fashion after four years' rotation. As we know that the soils of this colony are usually rich in nitrogen, we cannot but think that the cause of their improvement lies in the modification of the soil layer by another fertilizing agent. It is certain that the transformation of the mass of foliage into humus, through several years' successive decomposition, must have acted in a favourable manner on the arable layer.

Modern research has thrown new light on this subject.

Professor Dietrich Meyer, of Magdeburg, cultivated wheat, barley, oats, lupin, vetch, &c., in vessels filled with soil previously dosed with the nutritive elements which are soluble in weak acids. He observed that the soil in which the Leguminosæ had grown contained more soluble phosphoric acid, potash, and lime than that in the vessels containing the cereals. It is to be presumed that in operations on a large scale a crop planted in soil which has carried a leguminous plant benefits from the dissolving of the mineral elements brought about by the latter, which, according to the researches of Bernard Dyer, possesses more radicular acidity than others, such as cereals, crucifers, &c.

The humus resulting from the decomposition of the Leguminosæ is naturally superior to that of the Graminæ, *Panicum maximum*, *Cynodon dactylon*, the reason being that lime, magnesia, potash, phosphoric acid, &c., account for three-quarters of the mineral matters contained in the Leguminosæ, silica only accounting for one quarter; whereas the ash of the Graminæ usually gives 75 per cent. silica and only 25 per cent. lime, potash, &c. We are indebted to M. Bonâme for the establishment of this fact, the result of numerous analyses made at the Station among both Leguminosæ and Graminæ. Our thanks are also due to M. Joulie for the comparison of the ash of Graminæ and

Leguminosæ contained in his valuable work on chemical manures in the production of fodder.

Apart from the fact that they contain a larger quantity of nitrogenous matter than the Graminæ and forage root crops, the Leguminosæ have the advantage of affording more lime and phosphoric acid for the rearing of young live stock and the production of milk, both of which require phosphate of lime.

Works on rational feeding often neglect the question of mineral matters in the estimation of the ingredients. The experiments of Professor Henry have shown this to be wrong.

In districts where a too heavy rainfall forms an obstacle to the proper fertilization of the flowers and to the maturation of the pods, it is advisable to take a green crop rather than to chance losing everything, as has actually occurred in our experimental fields with plots left for seed.

Our experiments, like all those carried out elsewhere, prove that a higher weight of nutritive units is obtained per hectare in the form of green fodder or hay than in the form of seeds.

Instead of taking the figures from our own trials as a basis, we will borrow those given by Mr. L. Newman, the agricultural scientist of the Arkansas Experimental Station, which show the average for five years (1898 to 1902):—

	1898	1899	1900	1901	1902
Rain (inches)	62·23 ...	36·32 ...	32·67 ...	22·15 ...	37·16
Hay, per hectare (lbs.)...	7,743 ...	7,236 ...	6,589 ...	9,176 ...	7,207
Seeds (hectolitres) ...	4·4 ...	4·9 ...	7·7 ...	10·2 ...	4·8

The only error we find to criticize in M. Desbassyns's method of rotations with the aid of the Leguminosæ, is that of allowing the soil to remain for several successive years under the foliage of the same plant, as after this plant had once reached the period of florescence in any one year it would no longer improve the soil. The reason is that it no longer abstracts nutritive elements from the soil

and no longer lays up stores of nitrogen. One portion of the original plants remained and the other was replaced by the sowing which was naturally effected by the seeds which escaped from the unharvested pods.

We have observed, by means of experiments, that the flowering periods of various peas sown in November are as follows:—

Jack bean	January 25th
Yellow cowpeas	February 2nd
Grey ,, ...	March 15th
Mucuna utilis, striped	,, 29th
Pois dragées	April 17th
Mucuna utilis, black	,, 19th
,, white	,, 23rd
Lima bean	,, 24th
Phaseolus helvolus	May 1st
Dolichos lablab	,, 8th
Pois du Cap	,, 8th

There exists a prejudice in regard to the cultivation of Leguminosæ which, in the interest of agriculturists desirous of improving their land, we must endeavour to combat.

Because the Leguminosæ are plants which enrich the soil, numbers of people imagine that they stand in no need of farmyard or mineral manure, and that they are able to grow in any plot of ground whatsoever. When analysis has shown that the ash of Leguminosæ contains more lime, potash, and phosphoric acid than that of the Graminæ, it means their requirements in these elements are greater than those of other plants; in the same way they are extremely sensitive as regards the composition of the soils in which they are intended to grow. Black matter, or matter containing humus, is a great source of profit to them, and if some planters have been unsuccessful with their sowings of peas the reason often lies in the poverty of the soil, which might and should have been supplied with phosphoric acid and potash, &c.

Of two adjacent plots sown on the same day, *i.e.*, November 8th, 1908, with *Phaseolus helvolus*, both of which

had been under maize from March to July, 1908, one had received, in view of the crop of cereal, a light dressing of liquid manure. The effect of this latter on the growth of the maize and the production of grain was so good that it might have been supposed that practically the whole of the additional nutritive matters had been assimilated, and that consequently subsequent cultivations would feel no effects. The result was quite the opposite. As soon as the plant leaves were formed a large difference in their coloration became evident, and at harvest time there was a difference in the weight of green matter obtained. Indeed, the allotment which had been manured seven months previously gave over 55,600 kilos of green fodder per hectare, whereas its immediate neighbour only yielded 34,800 kilos. If we calculate this surplus due to the manure remaining in the soil as a percentage we get 59·5 per cent. This is a splendid figure and should convince planters of the benefit that restorative Leguminosæ are able to draw from a sufficient provision of nutriment.

This theory of manuring Leguminosæ may cause some surprise, but when we take into account the interest lost on the capital represented by fields of four and five hectares left under a rotation crop for one or two years, as is the custom in some countries, it is certainly more advisable to choose Leguminosæ which develop in a rather short time and which reach a maximum development with a slight manuring. There is no monetary loss; on the contrary, not only does the plant fix a large amount of nitrogen, but when ploughed in during florescence the mineral matter is returned to the soil.

In view of the necessity for obtaining the greatest possible profit from the soil by the cultivation of a plant of economic value like the sugar-cane, one cannot advise long rotations of several years' duration, such as were recommended and practised in earlier days. M. Bonâme has already deprecated this custom in his report for 1897, when he said: "We cannot understand why so much importance is attached to

a permanent covering, such as is obtained from the Lima bean, if the benefit from such covering is attained in a shorter period."

In 1898-99, M. Bonâme laid still further stress on this point: "The Lima bean is a most valuable plant for restoring the fertility of worn-out soils; but although the improvement in the soil is in relationship with the duration of the covering, it is not always economical to retain it for a number of years, and there comes a moment when the improvement produced is no longer in agreement with the loss represented by unproductive land."

One can only then advise, in fields needing green dressing, the cultivation of a leguminous plant for a period not exceeding a few months, *i.e.*, after the preparation of the land and before the planting of the main crop. In this way the fields would only remain unproductive for nine months instead of a year or a year and a half. Or the legume might be planted at the same time as the main crop (in alternate rows), this latter method being the one followed ever since the pea-nut became a marketable crop.

In fields where Leguminosæ are being grown, either for green manure or as fodder for live stock, a light manuring will be of great service. When the amounts of lime, potash, phosphoric acid, and magnesia acquired by our Leguminosæ in a period of four to six months are compared with those abstracted by a crop of canes of fifteen to eighteen months' standing, it becomes evident that the former have the larger appetites, and we can easily understand the reason for manuring soils which are to be planted with Leguminosæ.

When the crop is only intended for green manure there is no withdrawal of mineral matters; in fact, on ploughing the crop under, the soil is enriched by a considerable sum of organic matters.

The following table gives an idea of the contribution of organic matter per hectare, sums which, averaging the

different varieties, is equivalent to the application of 35 to 43 tons of farmyard manure to the hectare.

At the same time we see the rate at which decomposition takes place.

ORGANIC MATTER PER HECTARE.

	Decomposition of the leaves and stems left on the fields: Date of reaping Kilos	8 days later Kilos	15 days later Kilos
Mucuna utilis ...	277	73	31
,, ...	289	69	24
Jack bean ...	88	—	19
,, ...	81	—	17
Cowpeas, yellow	609	62	24
,, ,, ...	640	71	26
,, grey...	531	—	73
,, ,, ...	535	242	57

	Kilos
Cowpeas, yellow	6,400
,, grey	9,470
Jack bean	8,361
Mucuna utilis, black ...	8,491
,, white ...	7,747
,, striped ...	6,222
Lima bean	4,738
Pois dragées	2,606
Phaseolus helvolus	9,880

The following tables show the different proportions of lime, magnesia, potash, and phosphoric acid contained in the ash, dry matter, green matter, and the amount of these elements abstracted per hectare:—

In 100 parts of pure ash	Lime	Magnesia	Potash	Phosphoric acid
Cowpeas, yellow	22·84	4·92	26·87	8·72
,, grey	25·62	6·72	32·76	9·45
Jack bean	29·91	2·22	27·61	12·37
Mucuna utilis, black ...	15·39	4·40	34·12	7·44
,, white ...	14·03	4·07	32·87	8·10
,, striped ..	17·44	5·26	30·53	7·35
Phaseolus helvolus ...	18·47	4·23	29·51	10·86
Lima bean	18·06	4·80	32·20	10·61
Pois dragées	18·90	5·87	31·51	9·63

In 100 parts of dry matter	Nitrogen	Lime	Magnesia	Potash	Phosphoric acid
Cowpeas, yellow	3·36	2·772	0·597	3·262	1·058
,, grey	3·03	2·818	0·739	3·603	1·039
Jack bean	3·00	3·024	0·225	2·792	1·252
Mucuna utilis, black ...	2·90	1·347	0·385	2·986	0·651
,, white ...	3·21	1·246	0·362	2·919	0·720
,, striped ...	3·90	1·211	0·365	2·119	0·511
Phaseolus helvolus ...	2·77	1·973	0·452	3·158	1·160
Lima bean	2·23	1·768	0·480	3·153	1·039
Pois dragées	3·12	1·890	0·587	3·151	0·963

	In 100 parts of natural substance				
	Nitrogen	Lime	Magnesia	Potash	Phosphoric acid
Cowpeas, yellow	0·38	0·316	0·068	0·373	0·121
,, grey	0·43	0·400	0·104	0·511	0·147
Jack bean	0·75	0·755	0·056	0·698	0·313
Mucuna utilis, black ...	0·50	0·233	0·067	0·516	0·112
,, white ...	0·54	0·210	0·061	0·491	0·121
,, striped ...	0·72	0·223	0·067	0·390	0·094
Phaseolus helvo us ...	0·55	0·390	0·089	0·625	0·229
Lima bean	0·36	0·285	0·076	0·509	0·168
Pois dragées	0·38	0·231	0·071	0·385	0·117

FERTILIZING ELEMENTS ABSTRACTED PER HECTARE.

	Lime	Magnesia	Potash	Phosphoric acid
	Kilos	Kilos	Kilos	Kilos
Cowpeas, yellow	253·5	54·5	298·3	96·7
,, grey	241·7	63·3	309·2	89·1
Jack bean	281·2	20·8	259·9	116·3
Mucuna utilis, black ...	122·0	34·8	270·6	59·2
,, white ...	105·7	30·8	247·3	60·9
,, striped ...	62·8	21·1	122·0	29·4
Phaseolus helvolus	218·4	50·0	349·5	128·4
Lima bean	90·3	23·9	160·9	53·1
Pois dragées	55·7	17·3	92·9	28·4

COMPARATIVE TABLE OF THE VARIOUS ELEMENTS ABSTRACTED BY A CROP OF 71,000 KILOS OF TOPPED CANES TO THE HECTARE, AND BY LEGUMINOSÆ.

	Lime	Magnesia	Potash	Phosphoric acid
	Kilos	Kilos	Kilos	Kilos
Lousier (canes and leaves) ...	51·62	43·36	95·31	18·08
Big Tana	53·88	53·97	180·13	23·08
Port Mackay	42·95	44·07	216·02	21·11
Average of the nine foregoing varieties of Leguminosæ ...	158·97	35·06	234·55	73·45

The attention of planters has not yet been sufficiently aroused as to the necessity of introducing magnesia into manurial mixtures. We are of the opinion that in places where there is an abundant rainfall the supply of this element is insufficient, especially when there is a seed crop in view.

The particular demand we make of the Leguminosæ is that they should fix atmospheric nitrogen and store it up in the soil. Consequently, the more active the growth the better will be the general development, and the better will the plant perform its chief function, *i.e.*, the fixation of atmospheric nitrogen.

It is impossible to pay too much attention to Leguminosæ

whilst they are young. They are very sensitive to weeds at this stage, and it is essential that they should be disencumbered of them if they are to play their part later on of smothering plants in their turn. Through neglecting to hoe a plantation of peas in the first months of its growth, one often finds a field where this plant, by its irregular growth, has not accomplished the object for which it was sown.

In estimating the advantages of a rotation of Leguminosæ, plants which the early planters called *couvertures* (covering plants), we should not merely regard the enrichment of the soil as the sole effect. Indeed, we often find in the popular nomenclature of planters a definition of facts or of things so exact as to astonish us. In climates such as ours the violent rains, unparalleled in Europe, and the intense heat of the sun, are neither of them favourable to the soil, a medium which, as recent scientific agricultural research has shown, is full of micro-organisms which modify the condition of the arable layer. It is, therefore, a good thing at the commencement of the winter season to interpose between earth and sky a sort of insulator, a kind of blanket, or, as our ancestors called it, *couverture*. In this way the rain water is unable to block up the interstices between the particles of earth and to cause the soil surface to congeal, thereby retarding the development of the young plants. We ourselves have remarked that after a few days of heavy rain the fields turn pale and yellow. M. Joseph Desbassyns observed the same thing. In fact, among his instructions for the cultivation of the sugar-cane we read the following :—

"After a downpour the ground should be hoed at once. I have noticed that after heavy rains which have beaten down the soil the second crop of canes turns yellow if a turn with the hoe is not given immediately, even though the field has been hoed just previously."

That is one of the reasons for advocating the cultivation of cowpeas or peas between rows of canes.

Another matter on which the scientist of Bourbon was not able to speak is the stoppage of the work of the micro-organisms through the closing of the pores of the soil, which must undoubtedly be prejudicial to the growth of the crop.

The fact that the Lima bean is now considered the best covering is due to M. J. Desbassyns. It lasts for several years and its growth is always active. In dry localities its growth ceases in the very dry months, but picks up again very quickly at the first rains. M. Bonâme has already referred to it in his report for 1898-99.

We cannot conclude without summarizing our few remarks in these words: *The practice of rotation in our fields is indispensable.*

This necessity will be construed, firstly, by choosing Leguminosæ of rapid growth and restricted habit, so that they may be planted between canes and either ploughed in as green manure when in flower or harvested for seed; secondly, by using Leguminosæ with a large yield in the green state when the crop is to remain down for nine months; and further, if the maximum is to be obtained, by applying a slight dressing of manure to the plantation.

We append in a final table the amounts of seed required for a spacing of Leguminosæ at 66 cm. and 1 metre intervals. In view of the advantage accruing from a close plantation and the small quantity of seed required there can be no hesitation under the pretext of economy, the cost price of the seed being insignificant.

Two or three seeds should be sown together, and while the first hoeing (the only one required if the conditions are good) is being made, the plant or plants which appear to be weakest can be removed, leaving only one. This work can be carried out at a very small cost by boys, and the outlay occasioned by the use of three seeds in a group, which some might regard as useless, is balanced by the more complete development of the plant remaining. Our experiments have proved this.

However, as we have explained already, the whole of the plants may be left, if so desired, in order to cover the soil more rapidly.

	Average weight of a seed	Total seed to the arpent ('422 hectare) 0'66 × 0'66 cm.		Total seed to the arpent ('422 H 1 metre × 1 metre	
	Gramme	2 plants per pocket Kilos	3 plants per pocket Kilos	2 plants per pocket Kilos	3 plants per pocket Kilos
Phaseolus helvolus	0'099	1'971	2'956	0'880	1'320
Indian cowpeas	0'126	2'509	3'763	1'120	1'680
Cowpeas, grey	0'172	3'424	5'136	1'520	2'280
,, ,, yellow	0'183	3'643	5'465	1'620	2'430
Pois dragées	0'411	8'183	12'270	3'650	5'475
Lima bean	0'435	8'660	12'990	3'865	5'802
Mucuna utiiis, black	0'742	14'800	22'160	6'600	9'900
,, striped	0'815	16'100	24'150	7'250	10'925
,, white	0'855	17'020	25'530	7'600	11'400
Dolichos lablab	0'257	5'110	7'665	2'285	3'432
Pea-nut	0'765	15'200	22'800	—	—
Jack bean	1'261	25'100	37'650	11'200	16'800

CHAPTER IX.

LEGUMINOSÆ IN THE FEEDING OF LIVE STOCK.

THE Leguminosæ (whether in the form of green fodder or of hay) occupy a special position in the feeding of domesticated animals, through their high content of nitrogenous matter, which marks them off from the Gramineæ or other food mixtures.

Nitrogenous matter possesses considerably more value than the other nutritive elements, such as sugar, starch, and fat, not merely because it is rarer, but because it helps to form the plastic elements of the body, particularly in young, growing animals. Further, it may be regarded as being concerned in the control of the compounds which we know as carbohydrates.

From the very beginning of the foundation of the science of rational feeding (an essentially French science, seeing that its pioneers were Lavoisier, Boussingault, Dumas, &c.), the nitrogenous matter was considered as the most valuable nutritive constituent. It was for this reason that it was christened *protein*, derived from the Greek word πρώτειος, signifying first.

Formerly, in the feeding of domesticated animals, the nitrogenous matter was considered as being, one might say, the only one of value. Obviously, with the advent of physiological research, showing that the source of muscular energy resided in sugar and other bodies which, after becoming hydrated, were converted like sugar into glucose, the nitrogenous matter, rightly enough, lost its exclusive value. Nevertheless, in view of its rarity, it was still quoted at a higher price than the remainder.

One of the reasons why the fodder of Leguminosæ is superior to that of other plants is because their ash, containing less silica and considerably more lime, contributes to the rapid formation of the skeleton, and gives to the young live stock that early development at which all breeders aim.

In order to determine in a rational way what 100 kilos of Leguminosæ, either in the form of green fodder or of hay, represent, we must find out the number of nutritive digestible units they contain. This is because it is not that which is swallowed by a man or a beast that really forms a nutriment, but that which is digested, and consequently assimilated by the organism, that is to say, rendered similar to the organism itself.

Once we know what number of nutritive units a fodder contains, or to be more explicit, how many pounds of carbohydrates, fat, and nitrogenous matter, we may, knowing the cost of our usual diet, assign to it a pecuniary value based on scientific principles, and not on fancy, and either increase or decrease the value of this fodder at will. Briefly, we must have a standard of comparison.

As we are dealing with the Leguminosæ, shall we take the grain, oats, or bran which are given to live stock and which are imported from other countries, or shall we have recourse to a local food?

It is certainly preferable to base our calculations on the cheapest colonial product. At the same time, we can see beforehand that the product we shall get, being what is called a concentrated product, that is, richer in one principle than in others, will only really be a guide as to one single principle, either sugar, say, or nitrogenous matter.

We shall therefore have recourse to two products of different origin, molasses and oil-cake.

M. Bonâme, in his report for 1895, some considerable time before the publication of different works on sugar in the rational feeding of live stock, demonstrated the value of molasses in this connection, and showed how by their

fluid natüre they met the difficulties of the case. At this time no experiments had been made on the employment of this sugar by-product, and there was no knowledge of the fact that organic matters, other than saccharose, fats and nitrogenous matter, which form, so to speak, the non-sugar, had a particular value. Consequently, up to that date it was the sugar especially which represented the sum total of the cash value of this product, and it followed that each unit represented a higher figure than it really should have done.

It is to M. O. Kellner, Director of the Moekern Station, that we owe the definite and rational determination of nutritive matters. According to older writers, the nitrogenous matter, in being regarded as of five times the value of carbohydrates, starch, or sugar, was rated too highly. This scientist restored the balance by gaining acceptance for the fact that from the physiological point of view, at any rate as far as adult animals are concerned, the kilo of protein was equivalent to 940 grams of starch or of sugar, whilst the fat was worth 2·12 to 2·42 kilos, according as to whether it was derived from coarse or concentrated fodder. There is a difference between the physiological value and the pecuniary value, and, in the calculations made by O. Kellner, it is admitted that the nitrogenous matter being rarer, should command a higher price. This surplus value is estimated at three-quarters of the weight of the nitrogenous matter. Kellner has found from his experiments that the fat of fibrous fodders, hay, roots, &c., amounts to 1·91 kilos and the fat of concentrated products to 2·41 kilos.

Kellner thus expresses the sum of digestible principles as the *starch equivalent,* which he denotes by a single number. The result is a great simplification in the establishment of the ration; further, we see that the crude protein is not all digestible because, compared with pure albumen, the digestible protein matter of the foods contains various nitrogenous products, such as starch compounds,

which have not the same value in animal feeding as the albumen properly so called.

Let us determine the value of the sugar unit in a feed containing molasses, which we will take as a standard of comparison.

In his report for 1895, M. Bonâme gives the average composition of molasses:—

Water	26·37	per cent.
Ash	6·87	,,
Organic matter	19·90	,,
Sugar	27·65	,,
Glucose	19·21	,,
	100·00	

We find then:—

Nitrogen	0·31	per cent.
Water	26·37	,,
Ash	6·87	,,
Nitrogenous matter	1·88	,,
Nitrogen-free extract	18·02	,,
Sugar	27·65	,,
Glucose	19·21	,,

	Digestible	In starch
Nitrogenous matter	0·95 × 0·94	0·88
Nitrogen-free extract	58·39 × 0·94	54·98
		55·86

On adding three-quarters of the nitrogenous matter we shall obtain the cash value, because the nitrogenous matter is rarer, and should therefore command a higher price, 55·86 + 0·66   56·52 nutritive units.

The actual average price is Rs. 3.50 per cask of 180 litres, *i.e.*, Rs. 1.94 per 100 litres, or 140 kilos, which equals Rs. 1.38 per 100 kilos.

Therefore 100 kilos of molasses are equivalent to 56·52 nutritive units, expressed as starch. According to this, if 56·52   Rs. 1.38, 100 nutritive units will be worth Rs. 2.45, which brings the nutritive unit to R. 0.0245.

If we take the nitrogen value in molasses, our figure will really be too low, because the nitrogenous matter only

represents about a sixtieth part of the nutritive units of molasses.

We will therefore take the pea-nut cake (a by-product of the oil industry) and investigate how much the kilo of nitrogenous matter is worth at the present selling price of the cake.

Example.—We borrow from M. Bonâme's report on the pea-nut the following composition of pea-nut cake :—

Water	14·25
Ash	7·90
Cellulose	8·17
Nitrogen-free extract	21·38
Fat	7·99
Protein	40·31
	100·00

Commercial value : Rs. 120 per ton, or about Rs. 12 per kilo.

We shall then have :—

Digestible cellulose	1·06	19·10
Nitrogen-free extract	18·04	
Digestible fat	7·19	
„ protein	36·59	

Converted into starch we shall find as nutritive units :—

Nitrogen-free extract	17·95
Fat	17·32
Protein	34·39
Add three quarters of the nitrogenous matter	25·79
	95·45

Thus, 95·45 nutritive units expressed in terms of starch are worth Rs. 12, 100 units will be worth Rs. 12.57, and the unit Rs. 0.1257 :

		Rs.
Nitrogen-free extract	= 17·95 × ·1257 =	2.1778
Fat	= 17·32 × ·1257 =	2.2566
Protein	= 60·18 × ·1257 =	7.5649
		11.9993

As this cake contains 36·59 per cent. of digestible protein, if we divide Rs. 7.565, the cash value of the protein, by 36·59, we shall obtain the value of the kilo of nitrogenous matter in the cake, that is to say, Rs. 0.205.

With these two factors as a starting point we have established the price of our leguminous fodders according to Kellner's method. This method has been approved by M. Grandeau, the pioneer in France of the rational feeding of live stock. M. Grandeau has been instrumental in spreading a knowledge of the work of German experimental stations and of that of the Rothamsted scientists, Lawes and Gilbert, and he himself has added to our knowledge of the question by his lectures at the Conservatoire des Arts et Métiers, and by his agronomic articles published in the *Temps*.

The value of the Kellner method has been demonstrated by others as well, and tables appear in various French agricultural publications.

Professor A. Mallèvre, of the Institut agronomique, has helped to get the method adopted by breeders.

As soon as we had established the value of a leguminous plant, either in the green condition or in the form of hay, by means of these factors Rs. 0.02 and Rs. 0.20, we remarked at once the great difference between them. Wishing to follow modern research which tends to give such a small amount of difference between the nutritive principles, we found by our calculations that the unit of nitrogenous matter was worth Rs. .091, the fat Rs. .105, and the carbohydrates Rs. .053. These figures represent the average for the fodders quoted.

In order to obtain this result, the whole of the digestible matters is first converted into starch, and the protein being, from the monetary point of view—rarer and dearer, three quarters of the protein are added.

This sum of nutritive matters is equivalent to the price of 100 kilos of fodder, and in order to establish the total amount of each of these three elements we must first ascertain the value of the 100 nutritive units. The sum total of the three will give us the initial price of the fodder; but, as fodder is bought according to its content of digestible matters, we shall divide the figure for each element by its

digestible proportion and we shall have the unit of fat, the unit of protein, and the unit of carbohydrates.

Let us take as an example the yellow cowpea, the value of which is Rs. 3.18 per 100 kilos of hay.

			In starch
Digestible cellulose + carbohydrate	...	33·37 × 0·94	31·37
Digestible fat ...	... ...	1·40 × 1·91	2·78
Digestible protein	... ...	12·88 × 0·94	11·54
		+ 3/4	8·64
			54·33

If 54·33 units are worth Rs. 3.18, 100 units will be worth Rs. 5.85, and one unit Rs. .0585.

	Rs.
31·37 × ·0585	1.835
2·78 × ·0585	0.165
20·18 × ·0585	1.180
54·33	3.180

Rs.			
1.835	...	33·37 digestible carbohydrates	5·5
0.163	...	1·46 digestible fat ...	11·1
1.180	...	12·88 protein ...	9·6

Ever since the pioneers of the science of rational feeding attributed a preponderance of value to protein, the other matters were regarded as inferior, and for a time even the cellulose and the woody portion of the plant were considered to be useless. However, experiments on the digestibility of nutriments founded on the difference in the analysis of fodders eaten and of the excrement resulting from these fodders, that is to say, from the portion assimilated, showed that, in classes of more or less coarse fodders, a portion of the cellulose was converted into sugar and thus digested. Further, the whole of the carbohydrates did not enter into the organism. These facts having been established the total assimilable cellulose and carbohydrates were thenceforward included in feeding tables under the designation of digestible nitrogen-free extract.

We have, therefore, in the appended tables, taken these facts into account in estimating the non-nitrogenous matter.

The coefficients of digestibility for our local fodders have not been established experimentally as we could have wished, owing to our not having the necessary organization for such researches. They have been taken from American coefficients for fodders of the same sort, such as the cowpea, Bengal bean, &c.

COEFFICIENTS OF DIGESTIBILITY.

Green Fodder.

Cellulose supplementary to the carbohydrates ...	67 per cent.
Fat	62 ,,
Nitrogenous matter	70 ,,

Hay.

Cellulose	43 per cent.
Non-nitrogenous matter	71 ,,
Fat	50 ,,
Nitrogenous matter	65 ,,

The reader, when he sees that the coefficients of digestibility of the nutritive principles in green fodders and hay are not identical, will gather that the former are the more digestible. The proof of this is that an animal, when given a choice between green cowpeas or cowpeas in the state of hay, will always prefer the former.

Although we have said that cellulose is partially digestible, we do not wish to imply that its presence in more or less large quantities has no influence on the digestibility of the other nutritive principles. It is certain that the stomach is severely taxed in order to absorb it, and its value as a food is thereby diminished.

Kellner's method in no way diminishes the value of the formula $\frac{\text{N.M.}}{\text{N.N.M.}}$,[1] which shows the relationship which should exist between the two categories of nutritive principles where the physiological requirements of animals are concerned, *i.e.*, in furnishing muscular energy, fat, or milk;

[1] $\frac{\text{Nitrogenous matter}}{\text{Non-nitrogenous matter}}$ (or nutritive ratio).

IN 100 PARTS OF GREEN MATTER.

	Dry matter	Ash	Cellulose (Crude)	Nitrogen-free extract (Crude)	Fat (Crude)	Nitrogenous matter (Crude)	Digestible carbohydrates	Digestible fat	Digestible protein	Starch equivalent	Cash nutritive value represented by molasses and cakes	Value per hectare calculated according to the price of molasses and cakes
											Rs.	Rs.
Cowpeas, yellow	11·45	1·39	3·30	3·99	0·37	2·40	4·88	0·22	1·68	6·57	0.44	279·6
,, grey	14·25	1·56	4·04	5·56	0·39	2·70	6·43	0·24	1·89	8·26	0.51	379·1
Jack bean	25·00	2·52	6·12	10·88	0·79	4·69	8·97	0·48	3·28	12·42	0.83	308·0
Mucuna utilis, black	17·30	1·51	7·19	5·08	0·39	3·13	8·22	0·22	2·19	9·12	0.59	315·1
,, white	16·84	1·49	6·72	4·72	0·54	3·37	7·66	0·33	2·34	10·02	0.62	310·4
,, striped	18·43	1·28	7·12	4·83	0·70	4·50	8·00	0·43	3·15	11·30	0.79	284·3
Pigeon peas	19·80	2·11	7·67	6·04	0·66	3·32	9·18	0·40	2·32	11·56	0.65	362·5
Lima bean	16·15	1·58	6·29	5·62	0·41	2·25	7·97	0·25	1·57	9·43	0.47	148·1
Pois dragées	12·21	1·22	4·27	4·04	0·30	2·38	5·56	0·18	1·66	7·12	0.43	103·8

IN 100 PARTS OF FODDER IN THE STATE OF HAY.

	Dry matter	Ash	Cellulose (Crude)	Nitrogen-free extract (Crude)	Fat (Crude)	Protein (Crude)	Digestible cellulose	Digestible carbohydrates	Digestible fat	Digestible protein	Starch equivalent	Cash nutritive value calculated on the price of molasses and cake	Value per hectare	Value of one unit: Fat	Value of one unit: Protein	Value of one unit: Carbohydrates
												Rs.	Rs.	Rs.	Rs.	Rs.
Cowpeas, yellow	90·0	10·93	25·92	31·32	2·93	18·90	11·14	22·23	1·46	12·28	45·69	3.18	256	·111	·096	·055
,, grey	90·0	9·89	25·55	35·16	2·46	17·04	10·98	24·96	1·23	11·07	46·52	2.97	346	·102	·090	·051
Jack bean	90·0	9·10	22·02	39·13	2·87	16·88	9·46	27·78	1·42	10·97	47·69	3.00	306	·101	·088	·050
Mucuna utilis, black ...	90·0	7·88	37·50	26·28	2·03	16·31	16·12	18·65	1·01	10·60	44·36	2.85	284	·103	·090	·051
,, white ...	90·0	8·00	35·95	25·08	2·90	18·06	15·45	17·81	1·45	11·73	45·01	3.07	284	·109	·094	·054
,, striped ...	90·0	6·25	34·82	23·57	3·42	21·94	14·97	16·73	1·71	14·16	46·36	3.53	256	·119	·102	·058
Pigeon peas	90·0	9·62	34·91	25·88	2·99	15·60	15·01	19·08	1·49	10·14	44·41	2.76	336	·101	·088	·050
Lima bean	90·0	8·82	35·06	31·32	2·26	12·54	15·07	22·33	1·13	8·15	44·89	2.42	126	·092	·078	·045
Pois dragées	90·0	9·00	31·52	29·70	2·23	17·55	13·55	21·08	1·11	11·40	45·28	3.01	100	·107	·092	·053

or where it is a question of the digestibility of the starch in starchy nutriments such as the potato and the manioc.

Besides, Kellner has retained this formula as only being applicable when it is a question of calculating the ration solely on the digestive principles.

In short, when it is wished to ascertain the cash value of a nutritive principle in a food one should first know how many nutritive units it contains, and the resultant figure is divided by the price. Such is the usual procedure.

M. Kellner, on the other hand, converts all the digestible matters into starch and adds to them three-quarters of the weight of the nitrogenous matter, because of the greater value of this latter. It is then seen how much each group comes to, and the product is divided by the quantity of nutritive principles contained. In this way it can be said that the nitrogenous matter in one fodder is worth so much, and in another so much. Similarly the value of the fat or carbohydrates may be calculated in a concentrated or in an ordinary fodder.

CHAPTER X.

FORAGE LEGUMINOSÆ.

A NUMBER of plants, which we have already discussed from a special point of view, deserve our attention from the point of view of their value as fodders.

The family of the Leguminosæ includes certain trees and shrubs of which the leaves form an excellent fodder, and which are therefore useful for pasturage, *e.g.*, the acacias.

We mention herewith not only those whose composition and alimentary value we have studied, but in addition a number of others which have been recorded as being of some economic use.

The wood of these plants is often used for fuel, and as their ash may be profitably employed on the fields, we have given the mineral composition of the Mauritian species.

PAPILIONACEÆ.

Astragalus (Undershrub).—There are a number of species of *Astragalus*, some used in agriculture and others for artistic and industrial purposes.

The species *Astragalus arenarius*, from Western Asia, is a perennial forage plant occurring in sandy soils.

Astragalus Cicer is a green forage well liked by cattle.

Astragalus glycyphyllos and *A. hypoglottis* are excellent forages best suited by somewhat calcareous soils.

In the United States *Astragalus hypoglottis*, *A. caryocarpus*, *A. canadensis*, *A. adsurgens* are included among the useful forage plants.

Cajanus indicus (Shrub).—The pods and leaves of this plant are relished by live stock. The analysis of the pods has already been given; the composition of the leaves and branchlets is as follows:—

Water	56·65 per cent.
Ash	1·76 ,,
Cellulose	15·49 ,,
Fat	1·12 ,,
Non-nitrogenous matter	20·12 ,,
Nitrogenous matter	4·86 ,,
	100·00

Crotalaria (Shrub). Cattle do not appear to have any relish for this plant, but there are a few exceptions. For instance, we may cite *Crotalaria juncea*, which is given to milch cows, and *C. Burhia*, a small legume of the sandy desert plains, which is eaten by camels.

The proximate composition of *Crotalaria juncea* in the state of hay is as follows:

Water	14·39	per cent.
Ash	9·94	„
Cellulose	27·39	„
Fat	1·12	„
Non-nitrogenous matter	32·85	„
Nitrogenous matter	14·31	„
	100·00	

Nitrogen = 2·29, of which 1·99 is in the form of protein, say 86·9 per cent.

Cytisus proliferus (Shrub). This legume, of which the common name is *tagasaste*, is a forage plant which has acquired a large range in the Canary Isles. It is a small tree with white flowers, and from the young stage onwards gives numerous leafy branches, tender and pliant, which are devoured by cattle.

Propagated by seeds this plant thrives well everywhere, grows anew after having been cut, and owing to its extensive root system is well able to withstand drought.

The yield of *tagasaste* is very high and equal to that of the most productive fodder plants. It is cut three times yearly, and may be converted into hay. The beasts which feed on it grow fat, but are lacking in muscle. It occurs in Algeria and throughout the whole of Northern Africa.

Dalbergia (Tree). M. Raoul states in his work that the leaves of the species *latifolia*, *Sissoo* and *volubilis* may be given to live stock.

Desmodium (Shrub). All the species of *Desmodium* make excellent fodders, but some are of particular interest, such as *D. penduliflorum* and *D. tiliæfolium*. The variety *gangeticum* is also a forage plant, but should be given with discrimination, as its leaves are too tough and might be the cause of trouble. Details as regards *Desmodium* have been given in another chapter.

Dolichos scarabœoides (Liane). This is a trailing herbaceous plant which occurs in the pastures of Mauritius and is distributed through tropical Asia, Madagascar, and Bourbon.

Cattle graze it along with other herbs. Its composition is as follows:—

Water	69·35	per cent.
Ash	2·34	„
Cellulose	9·72	„
Fat	1·41	„
Non-nitrogenous matter	12·89	„
Nitrogenous matter	4·29	„
	100·00	
Nitrogen	0·69	„

Galactia (Herb).—The genus *Galactia* contains small herbaceous plants with trailing stems which grow wild in some districts of Mauritius. It is good feed; unfortunately the plant is not of tufted habit and only affords a very slight amount of foliage; the leaves are downy.

Several varieties occur, such as *Galactia sericea*, a native of Mauritius and Bourbon; *G. diversifolia*, indigenous to Madagascar, the Comoros and Mauritius, grows on the savannahs and on the mountains. They grow during the rains and flower in February and March.

The composition of the *Galactia* harvested at Réduit is as follows :—

	In 100 parts of dry matter	In 100 parts of natural substance
Water	- -	70·20
Ash	7·93	2·36
Cellulose	24·90	7·42
Fat	5·50	1·64
Sugars	traces	traces
Non-nitrogenous matter	46·55	13·88
Nitrogenous matter	15·12	4·50
	100·00	100·00
Nitrogen	2·42	0·72

The content of mineral matters is as follows :—

	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of natural substance
Silica	11·80	0·935	0·278
Chlorine	1·10	0·087	0·026
Sulphuric acid	1·91	0·151	0·045
Phosphoric acid	3·82	0·303	0·090
Lime	28·80	2·283	0·679
Magnesia	5·02	0·401	0·118
Potash	29·08	2·306	0·686
Soda	2·58	0·204	0·061
Oxide of iron	4·31	0·342	0·101
Carbonic acid, &c.	11·58	0·918	0·276
	100·00	7·930	2·360

According to Baker, the above *Galactia*, which has reddish flowers, is *G. tenuiflora*.

Indigofera (Shrub).—As a rule animals pay scarcely any attention to the genus *Indigofera*, but the variety *I. ovina* should be recorded. It is a small, herbaceous, leguminous plant from the Cape and sheep and goats enjoy browsing it.

According to Roxburgh, two Indian species are forage plants, and at Cayenne cows eat *Indigofera anil*. var. *polyphylla*.

According to Watt, the fodder yielded by *Indigofera pauciflora* is relished by camels.

Jacksonia cupulifera (Tree). This plant occurs in the arid Australian deserts. It is a small tree, and gives a fodder which is greatly relished by horses and cattle. Several other varieties of *Jacksonia* are equally useful.

Lathyrus tingitanus (Herb).—This climbing leguminous plant grows wild in North America. It is a first-class fodder plant and thrives very well. It is sown at the beginning of the rains and its stems rapidly cover the soil; cattle eat it greedily.

Attempts should be made to acclimatize this legume in various sub-tropical countries.

Lotus corniculatus (Herb).—A splendid forage plant which thrives very well in Australia. There are several other varieties in the tribe of the Loteæ which may serve as forage plants.

Lotus corniculatus, the common Lotus, is not only indigenous in Australia, but also in North Africa, Central Asia, and the whole of Europe. According to Naudin, it has all the qualities of white clover and surpasses it by its faculty for resisting drought. This latter it owes to the length of its primary root, which penetrates deep into the ground.

Other species of Lotus have similar qualities.

Lotus villosus (hairy lotus) shows a greater development and affords more forage than the foregoing.

Lotus tetragonolobus (four-winged lotus) spreads very close to the soil and can only be grazed by sheep.

Lotus siliquosus is only eaten green. Productivity small.

Lespedeza striata (Herb).—A herbaceous leguminous plant known as Japanese clover. Highly valued as fodder in Japan, whence it has spread to a number of sub-tropical countries.

Lupinus (Shrub).—Lupins are very widely distributed plants and occur in the most varied climates. Their flowers vary in colour, and the chief varieties employed in agriculture are: *Lupinus albus*, *L. angustifolius*, *L. Termis*, *L. arboreus*, *L. luteus*, *L. varius*.

These varieties are not only restorative plants, but are also highly valued as fodder, whilst their seeds are sometimes used for human food. The seeds of *Lupinus luteus* are used for feeding cows and oxen and help to fatten them.

Lupins generally thrive fairly well in siliceous and volcanic soils. They are grown nowadays in gardens; dwarf and tall varieties occur.

According to M. Balland, the composition of the seeds of *Lupinus albus* is as follows:—

Water	8·10	per cent.
Ash	4·10	,,
Cellulose	10·15	,,
Fat	8·00	,,
Non-nitrogenous matter	35·63	,,
Nitrogenous matter	34·02	,,
	100·00	,,

Weight of 100 seeds, average	38·4 gr.
,, ,, ,, maximum	50·2 ,,
,, ,, ,, minimum	24·9 ,,

Medicago sativa (Herb). Lucerne is a forage plant which is valued very highly in Europe; it is a native of the country of the Medes, hence the name *Medicago sativa* (*media*). It is indigenous to Europe and has spread to all sub-tropical countries, where its success varies according to climate and cultural conditions.

It is cultivated in India, Hawaii, Australia, and notwithstanding its varying success in these different countries it still remains a forage plant of considerable interest.

This plant is sown at the commencement of the wet season. In order to obtain a good crop the soil must be deep, well drained, and free from plant growth. Owing to the depth to which the roots penetrate and the considerable size of the root-system, lucerne is able to withstand a considerable amount of drought and may live for several years. Wet soils are disastrous to this plant: the soil should be sufficiently porous to preclude the accumulation of water, which would injure the growth.

Considerable care should be exercised in selecting the seeds owing to the occurrence among them of those of a parasitic plant which is most injurious to the lucerne. The quantity per hectare varies according to the spacing of the rows and the method of sowing.

Flowering occurs five or six weeks after sowing, and reaping is begun immediately. Usually five to six crops are cut a year, but this number may vary according to local conditions. In Hawaii they reckon annually on from 24 to 48 tons of green forage per hectare, and according to M. Pond, the quantity of hay scarcely ever exceeds 16½ tons per hectare. In India, on the Poona farm, one of the best results obtained was 38 tons of green fodder.

There are several varieties of lucerne, the chief one, *Medicago sativa*, being commonly known as Alfalfa.

M. Krauss, of Hawaii, gives their composition to be as follows:—

Water	74·45 per cent.
Ash	2·87 ,,
Cellulose	7·47 ,,
Fat	0·42 ,,
Non-nitrogenous matter	8·75 ,,
Nitrogenous matter	6·04 ,,
	100·00 ,,

According to the same authority, the ash of 1,000 lb. of natural substance contains:—

Nitrogen	9 lb. 7 oz.
Phosphoric acid...	2 ,, 3 ,,
Potash...	6 ,, 3 ,,
Lime	3 ,, 4 ,,

This forage also occurs in India, and analyses have been made by Dr. Leather. We see that it contains less nitrogen and is less fibrous than that from Hawaii or Mauritius.

Water	77·75 per cent.	78·32
Ash	2·86 ,,	2·56
Cellulose	3·74 ,,	3·35
Fat	0·76 ,,	0·75
Non-nitrogenous matter	10·45 ,,	9·96
Nitrogenous matter	4·44 ,,	5·06
	100·00	100·00
Nitrogen	0·71 per cent.	0·81 per cent.
Protein nitrogen	0·48 ,,	0·61 ,,

The pods are spirally twisted and the contained seeds are quite small: 100 pods weigh 2·5 grm.

M. Balland's analysis of the fruit with seeds is as follows:—

Water	9·50 per cent.
Ash	4·90 ,,
Cellulose	21·80 ,,
Fat	4·30 ,,
Non-nitrogenous matter	40·55 ,,
Nitrogenous matter	18·95 ,,
	100·00

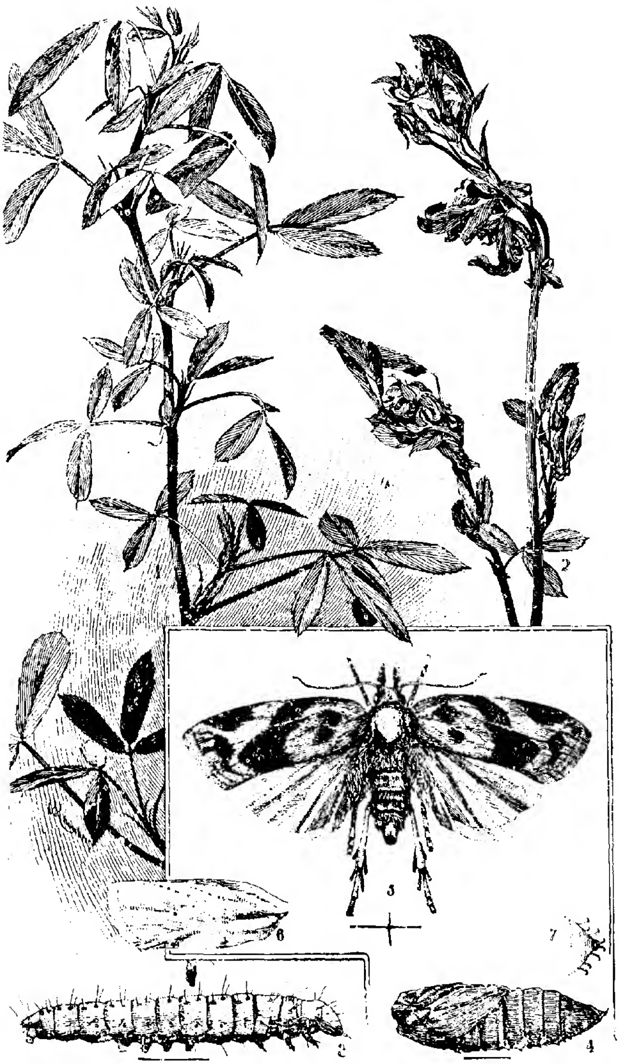
A few experiments have been made in Mauritius, and the average analysis is as follows:

	In 100 parts of natural substance	In 100 parts of dry matter
Water	75·90	—
Ash	2·14	8·92
Cellulose	8·18	34·02
Fat	0·98	4·03
Non-nitrogenous matter	8·07	33·35
Nitrogenous matter	4·73	19·68
	100·00	100·00

The mineral composition is about the same as that of other Leguminosæ:—

	In 100 parts of pure ash	In 100 parts of dry matter	In 100 parts of lucerne
Silica	1·48	0·133	0·031
Chlorine	4·50	0·400	0·060
Sulphuric acid	3·87	0·346	0·083
Phosphoric acid	6·59	0·590	0·140
Lime	18·53	1·647	0·398
Magnesia	6·47	0·576	0·139
Potash	33·44	3·007	0·718
Soda	1·53	0·137	0·032
Oxide of iron	1·50	0·139	0·032
Carbonic acid, &c.	22·03	1·945	0·471
	100·00	8·920	2·140

The species of *Medicago* have a wide distribution, and some are regarded as weeds, *e.g.*, *M. denticulata* occurring in Japan, United States of America, Chili, Africa, India, New Zealand, &c. Other varieties which occur in Africa are *M. lupulina*, *M. orbicularis*, *M. minima*, *M. laciniata*, *M. tentaculata*.



Agricultural Gazette, N.S.W.

FIG. 46.—*Tortrix glaphryiana* (Moth attacking Lucerne). 1, healthy plant; 2, infected plant; 3, larva; 4, chrysalis; 5, adult moth; 6, portion of wing; 7, anal segment.

The variety *lupulina* is found in India and America. Though of less importance than lucerne (*Medicago sativa*) it is still useful in mediocre soils which are subject to drought.

The other varieties which might be used as fodder are not quite as useful, as they are trailing instead of erect, and their productiveness is small.

M. Guthrie gives the following composition for *Medicago lupulina* :—

Water	72·76	per cent.
Ash	2·77	,,
Cellulose	4·29	,,
Fat	0·70	,,
Non-nitrogenous matter	12·48	,,
Nitrogenous matter	7·00	,,
	100·00	

Retama Raetam.—A leguminous fodder plant from the Sahara, with black and white flowers which impart their pleasant odour to camels' milk.

Melilotus (Herb). This plant, with trifoliate leaves, is usually considered as a fodder plant, but owing to its smell, cattle regard it with dislike, and they can only be made to eat it by mixing it with hay, and then only with difficulty.

Melilotus is not cultivated in warm countries. Several varieties occur, especially *M. officinalis*, and in Africa, on Nile soils, is found *M. parviflora*, which is now distributed over the whole globe, and regarded as a weed, like *M. gracilis* and *M. abyssinica*.

Bees are very fond of these plants, especially of *Melilotus alba*, which has large numbers of perfumed flowers, and is the cause of their producing a large amount of honey.

Certain cheeses are rendered aromatic with the flowers of *Melilotus cærulea*.

In India *M. parviflora* is employed as a fodder. Dr. Leather gives the following analysis of it :—

	Green fodder		Hay	
Water	84·40	per cent.	10·00	per cent.
Ash	2·26	,,	13·04	,,
Cellulose	4·13	,,	23·83	,,
Fat	0·36	,,	2·08	,,
Non-nitrogenous matter	6·16	,,	32·49	,,
Nitrogenous matter ...	2·69	,,	18·56	,,
	100·00		100·00	
Nitrogen	0·43	,,	2·97	,,
Protein nitrogen ...	0·42	,,	2·47	,,

Oxytropis pilosa (Undershrub).—A perennial leguminous plant from Western Asia. It grows in sandy soils and affords good fodder.

Pongamia glabra (Tree).—The leaves are used for fodder.

Psoralea plicata (Shrub).—M. Sagot records this plant as a fodder for camels.

Pterocarpus erinaceus (Tree).—This tree is very common in Senegal and the Soudan, and its leaves serve as fodder for sheep and oxen.

Sesbania ægyptiaca (Shrub).—A perennial plant occurring in Africa, Southern Asia, and the north of Australia. It is used as a fodder plant like the species *Sesbania brachycarpa*, which, according to Von Muller (Australia), is much relished by live stock.

Smithia sensitiva (Herb).—Roxburgh says that this little plant makes a very good fodder in India and is widely used. It is very tender and much relished by live stock. This variety, which is indigenous in Western Asia, has a wide distribution; it occurs in Africa with *Smithia capitulifera*—a similar plant which might also be used as fodder.

Sophora tomentosa (Shrub).—The seeds of this shrub are used in Madagascar for feeding purposes. Seeds harvested at Réduit gave the following figures :—

Water	13·56	per cent.
Ash	2·84	,,
Cellulose	19·60	,,
Fat	14·00	,,
Non-nitrogenous matter	39·70	,,
Nitrogenous matter	10·30	,,
	100·00	

The proportion of nitrogenous matter in these seeds is relatively feeble, but, on the other hand, the proportion of fatty matters is very high.

Stylosanthes (Herb).—A genus of Leguminosæ which is capable of providing fodder. In Guadeloupe horses graze *Stylosanthes erecta* with relish.

Swainsonia (Large Shrub).—*Swainsonia phacoïdes* and *S. procumbens* are both excellent forage plants in Tasmania.

Trifolium (Herb).—The genus *Trifolium*, known as clover, contains a large number of species. Some are natives of Europe, others of Africa, Asia, America, &c., and species occur among them which are very useful in agriculture. The principal species are forage plants of the highest order; they are widely distributed and very useful wherever they are cultivated.

Trifolium alexandrinum.—This leguminous plant is cultivated a great deal in Egypt, and forms the chief fodder there. It is annual in habit, and in some soils where it finds splendid growth conditions it may attain a height of 60 to 70 cm.

At the trial station of the Algerian Botanical Department, Alexandrian clover has given four crops in a year. When sown at the end of July the yield per hectare by the middle of September was

[*Photo G. Roland.*

FIG. 47. *Sophora tomentosa* (Stems and fruit).

28,000 kilos; in the middle of November, 20,000; shortly after the middle of February, 30,000; and at the end of May, 25,000. M. Trabut states in his report on experiments in agricultural botany made in Algeria during 1898 that this plant grows the whole year round, and only needs irrigating when a crop is wanted during the height of summer. In winter, along the littoral and in the south, its growth is very vigorous.

Trifolium subrotundum.—This plant is grown for fodder in the North of Africa.

Trifolium resupinatum.—This clover is cultivated in the North of India though it is hardly much of a forage plant. According to Naudin it occurs in North Africa, the Canaries, the Azores, &c.

The following varieties may be quoted: *T. Arvense*, *F. fragiferum*, *T. Steudneri*, *T. umbellulatum*, *T. quartinianum*, *T. acaule*, *T. procumbens*, *T. sinense*, *T. africanum*, *T. polystachyum*, &c.

The most important of all is the red or field clover, *Trifolium pratense*.

It is a plant which is sown over a wide area and devoured by live stock either in the green state or as hay. When used in the latter state care must be taken in view of the mishaps that may occur if it is wetted by rain or dew. In Australian experiments 7 to 9½ tons of hay have been obtained per hectare. Its composition was as follows, the analysis of green fodder and hay being due to M. Guthrie:—

	Green fodder	Hay
Water	70·8 per cent.	20·8 per cent.
Ash	2·1 ,,	6·6 ,,
Cellulose	8·1 ,,	21·9 ,,
Fat	1·0 ,,	4·5 ,,
Non-nitrogenous matter	13·6 ,,	33·8 ,,
Nitrogenous matter ...	4·4 ,,	12·4 ,,
	100·0	100·0

Clover is, further, a first-class restorative plant for impoverished soils. In England one speaks of "clover sickness," a malady which is easily remedied by the addition of phosphate and of potash. It is an established fact that this plant thrives well practically everywhere and the amount of attention given will vary according to the particular result required. It is biannual in habit and pastures resow themselves. Clover is a great nitrogenous fertilizer for the raising of wheat on medium soils, and in addition furnishes organic matter and opens the soil by means of its roots.

The seed is also eaten by cattle, that of the common variety being the most readily accepted, as the American one is heavier. The seed is an important article of commerce between America and Europe.

M. Balland has analysed the various portions of the plant for Europe: Twenty-six plants cut; maximum length 0·70 metres; weight 100 grm., of which the flowers were responsible for 17·30 grm.; the leaves 14·70 grm.; stems 68·00 grm.

	Whole Plant		Flowers		Leaves		Upper Leaves		Lower Leaves	
	Normal	Dry	Normal	Dry	Normal	Dry	Normal	Dry	Normal	Dry
Water ...	84·50	0·00	77·50	0·00	81·00	0·00	86·60	0·00	85·50	0·00
Ash ...	0·79	5·10	1·19	5·30	1·54	8·10	0·69	5·20	0·43	2·90
Cellulose ...	4·16	26·85	5·49	24·40	2·29	12·05	3·62	27·00	4·84	33·40
Fat ...	0·44	2·80	0·53	2·35	0·85	4·50	0·35	2·60	0·25	1·75
Non-nitrogenous matter	7·90	50·99	11·15	49·53	9·65	50·79	6·93	51·70	8·05	55·51
Nitrogenous matter ...	2·21	14·26	4·14	18·42	4·67	24·56	1·81	13·50	0·93	6·44
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

The seeds are round and very small, tawny in colour, with a smooth surface, and when chewed have the characteristic flavour of leguminous plants.

100 seeds weigh 0·167 grm.

Water	9·60 per cent.
Ash	2·80 ,,
Cellulose	5·80 ,,
Fat	8·20 ,,
Non-nitrogenous matter	42·44 ,,
Nitrogenous matter	31·16 ,,
	100·00

(Balland).

Trigonella Fœnum-græcum (Herb).—An annual fodder plant cultivated in Abyssinia which has spread to a number of countries. Its common name is *Fenugreek;* it grows wild in Asia Minor and in Persia.

According to M. Balland, this plant was cultivated by the ancient Greeks.

The seeds serve as condiments for man and some domestic animals. In Algiers and Tunis the natives regard them as digestive, body-building and aphrodisiac.

	I	II
Water	10·10 per cent.	10·80 per cent.
Ash	2·90 ,,	2·75 ,,
Cellulose	6·10 ,,	6·60 ,,
Fat	5·95 ,,	6·65 ,,
Non-nitrogenous matter	51·99 ,,	45·48 ,,
Nitrogenous matter ...	22·96 ,,	27·72 ,,
	100·00	100·00
Average weight of 100 seeds	2·18 gr.	2·03 gr.

The genus *Trigonella* includes a few species that might also be used as forage plants. *T. hamosa* is a plant occurring in Egypt, at the Cape, and in India; *T. occulta*, found in Egypt and Northern India; *T. laciniata*, an Egyptian species; *T. marginata*, Northern Africa; *T. suavissima,* a perennial species from New Holland which is eaten by live stock in spite of its odour.

Vicia (Herb).—The vetch is a herbaceous leguminous plant with a very wide distribution, and some varieties are of great economic value. Some climb by means of tendrils, others are of low growth.

Numerous varieties of vetch occur throughout the globe. They are forage plants, and in some the seeds are capable of being used for food. An annual species of low habit, *Vicia Ervilia*, is cultivated in North Africa; it is a forage plant and very prolific as regards seed production.

It is chiefly used for feeding horses, only a moderate amount being given on account of its heating properties. The seeds are given to poultry.

Vicia sativa.—This vetch, grown in Northern Africa and other subtropical countries, forms an excellent fodder. The seeds are used to feed pigeons, fowls, ducks, &c. It needs supporting by plants which have strong stems.

Vicia sativa grows wild in Europe. A. de Candolle gives it as a native of Northern India and Bengal.

The vetch has been cultivated from time immemorial; even in Cato's time it was known as a splendid fodder.

M. Balland ("Les Aliments") gives the weight of fourteen cut plants as 383 grm.; the husks weighing 70 grm., the leaves 175 grm., stems 138 grm. That is to say the percentage is as follows:—

Husks	18·3 per cent.
Leaves	45·7 ,,
Stems	36·0 ,,
	100·0

Its composition is as follows:—

	In the normal state	In the dry state
Water	75·00 ...	0·00 per cent.
Ash	1·81 ...	7·24 ,,
Cellulose	5·89 ...	23·56 ,,
Fat	0·62 ...	2·47 ,,
Non-nitrogenous matter ...	9·96 ...	39·85 ,,
Nitrogenous matter	6·72 ...	26·88 ,,
	100·00	100·00

Vicia sepium (Herb).—Suits damp climates; like the preceding, requires to be supported by stems.

Vicia tetrasperma (Herb).—Excellent forage plant. In tropical Africa are found the species *Vicia paucifolia* and *V. hirsuta.*

CÆSALPINIEÆ.

Bauhinia purpurea (Tree).—The leaves are eaten by live stock.

Bauhinia reticulata (Shrub).—Cows, sheep, and goats are very fond of this plant, which is widely distributed in Senegal and the Soudan.

Ceratonia Siliqua.—*Ceratonia Siliqua*, the common name of which is the carob tree, is a native of the East. It has a most luxurious

growth and sometimes reaches a height of 15 to 16 metres. The leaves are pinnate, strongly cutinized and dark green in colour. The flowers are reddish, small, and distributed in inflorescences grouped along the branch.

The plant is diœcious. The female plants yield curved pods from 10 to 25 cm. long and 2·5 cm. broad. Occasionally the tree is monœcious, but in order to ensure fecundity in carob trees grown from seed and which have no subsequent pruning, they should be planted in groups so as to have male and female trees on the same plantation. The establishment of a hive of bees will prove a powerful aid in the delicate business of fertilization.

The carob tree may be cultivated for the sake of cattle fodder, being especially useful in the bad season, and also as an ornamental and shelter plant against winds which would injure more delicate kinds of vegetation.

It is a slow-growing and exceptionally long-lived tree. It is said that trees over one hundred years old are still full of sap.

Ceratonia Siliqua grows well in all soils. According to the *New South Wales Agricultural Gazette*, it can be seen growing in soils of almost pure sand, in rich gravel and alluvial soils, or in well cultivated soils which are rich in humus. Nevertheless it does not thrive in hard, close soils.

The carob tree is propagated by means of seeds, root-stocks, cuttings, and grafting. The seed method is the easiest, and there are said to be several varieties of seed, some better than others.

Before sowing, the seeds are scalded in an earthenware vessel which is subsequently kept at a moderate temperature until the seeds are soft. This operation will take one or two weeks, the warm water acting more rapidly on some than on others. They are sown in tubs which are drained by means of a layer of charcoal placed at the bottom, and then watered moderately at regular intervals. They are transplanted seven months after sowing, but the best plan is to sow in the spot where the plant is intended to remain, taking care to water regularly and to keep down the weeds. The advantage of grafting is that the reproduction of female trees is certain.

The season for planting varies in different countries, and similarly the productivity of the trees varies according to the locality.

Graftings produce pods seven years later, while trees grown from seed are slower in fruiting. When from twelve to fifteen years old they will start bearing large quantities of beans.

Chambers notes that a single tree produced more than half a ton of beans in a season. Professor Church gives the following analysis :—

Water	14·6	per cent.
Albuminoid matter	7·1	,,
Sugars	51·8	,,
Carbohydrates	16·1	,,
Fat	1·1	,,
Cellulose	6·4	,,
Ash	2·9	,,
	100·0	

The nutritive ratio is 1 : 8·5, whilst the nutritive value is 68. As sugar, pectose, gums, &c., take the place of starch in these peas, the starch equivalent cannot be calculated in the usual way because sugar and the other substances contain less carbon, and have consequently less nutritive value.

Algerian specimens from the 1900 Exhibition have been analysed by M. Balland:—

	In 100 parts whole pods	In 100 parts seeds only	In 100 parts husks
Water	13·00	13·00	12·50
Ash	2·35	3·00	2·30
Cellulose	9·10	6·85	9·40
Fat	0·50	1·25	0·40
Saccharose and glucose ...	30·10	0·00	31·25
Non-nitrogenous matter ..	39·87	61·40	42·05
Nitrogenous matter ...	5·08	14·50	2·10
	100·00	100·00	100·00

One fine pod weighed 22·65 gr., and contained fourteen seeds weighing 2·65 gr.

The weight of the pods may vary from 8·6 gr. to 24 gr., the seeds accounting for 0·2 gr. to 2·4 gr. The latter only represent 10 per cent. of the weight of the pods.

In Tunis the natives feed on a mixture of wheat and carob. This mixture, of which there was a sample at the "Concours agricole de Paris" of 1902, had the appearance of a coarse powder.

M. Balland has made the following analyses of whole pods which contained seeds.

It will be seen that the proportion of sugar varies within fairly wide limits, the other elements remaining about the same:—

	Candia per cent.	Cyprus per cent.	Crete per cent.	Greece per cent.	Portugal per cent.
Water	9·20	11·00	12·00	10·80	11·80
Ash	2·20	2·10	2·08	1·96	2·00
Cellulose	10·50	8·10	7·85	9·50	9·15
Fat	0·55	0·40	0·35	0·50	0·50
Saccharose	21·74	28·57	8·20	29·40	17·56
Glucose	21·36	14·53	26·04	10·28	19·20
Non-nitrogenous matter	28·43	29·70	37·74	30·70	34·05
Nitrogenous matter ...	6·02	5·60	5·74	6·86	5·74
	100·00	100·00	100·00	100·00	100·00

When the carob bean or carob fruit is green it contains a big proportion of tannin, and is very astringent. In Algeria, when in this state, it is used for tanning the finest Moroccan leathers.

When mature the pods are brown in colour and fall spontaneously. In order to preserve them they must be dried; if they are heaped beforehand they will be impaired by fermentation and turned blackish.

England and France import fairly large quantities. Pigs, horses, and also milch cows and other animals will eat them; cows are said to give more milk as a result. During the Peninsular War the mules

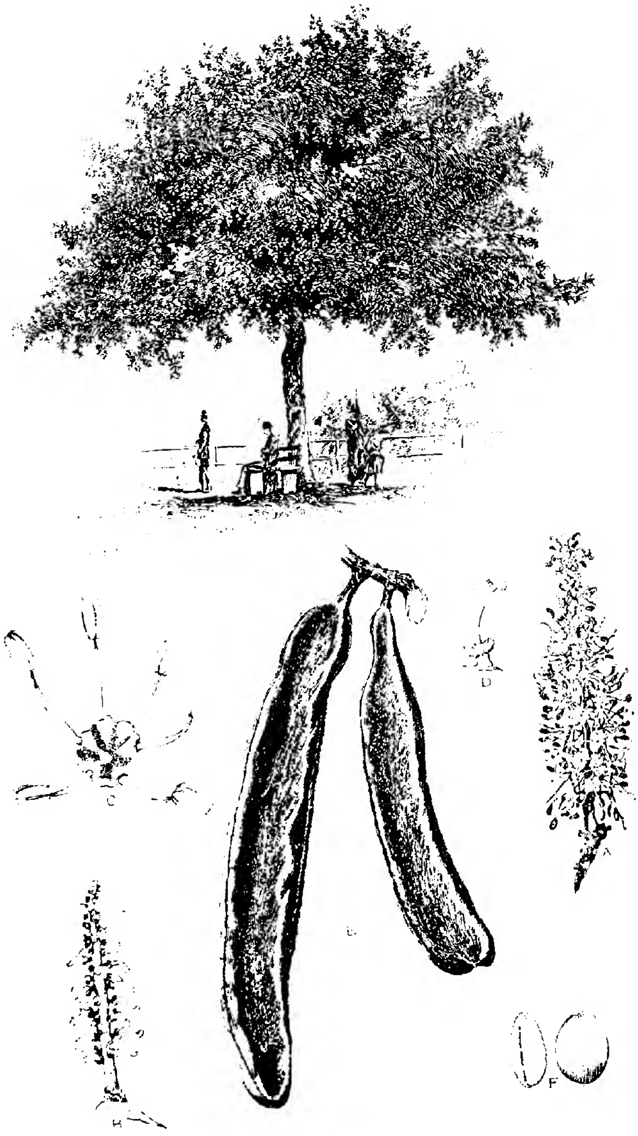


FIG. 48.—*Ceratonia Siliqua* (Carob Tree). A, male inflorescence; B, female inflorescence; C, male flower; D, female flower; E, pods; F, seeds.

and horses belonging to the English cavalry were fed entirely on the carob bean.

Wittmack states that the fruit is used in the manufacture of a pharmaceutical syrup. It is prepared and sold like chocolate.

According to Dr. G. Wittstein, this bean contains butyric acid. After distilling in the presence of sulphuric and phosphoric acid the product is precipitated in the form of barium butyrate, and the acid is obtained by removing the barium by means of sulphuric acid and

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FIG. 49. *Acacia*, sp.

subsequent rectification. This salt of barium butyrate contains 50·77 per cent. of acid.

Dr. de Hass, in his "Buried Cities Recovered," says that he is inclined to believe that the "wild honey" which was the basis of the diet of John the Baptist was none other than the fruit of the carob tree. In Palestine this fruit is known as *St. John's Bread.* In Arabia it is called *carob* because of its crescentic shape.

This tree is found throughout Palestine. It is an evergreen with

abundant foliage casting a delightful shade. The fruit is a common article of food with the natives. "While we were crossing the country," says Dr. de Hass, "our muleteers seemed to make these beans their only food." A record is generally kept of these trees and marriages are often dowered with carob fruits. A grove of these trees is regarded as having as big a value as a vineyard or an olive plantation. A single tree may produce a thousand pods. They are exported

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FIG. 50.—*Acacia aneura.*

to Russia and elsewhere. When the fruit is ripe it contains a sweet pulp, which is extracted and turned into a honey of a kind which is most popular among the peasants of Palestine. Dr. Brandis says that the wood of this tree is hard, heavy, an excellent fuel, and good for carpentry.

Hardwickia binata (Tree).—A large Indian tree. Animals are very fond of the leaves, which they browse directly from the pollarded trees.

Hardwickia Mannii (Tree).—A species peculiar to tropical West Africa. The leaves are eaten by cattle.

MIMOSEÆ.

Acacia aneura (Tree).—The leaves of this Australian member of the Leguminosæ are used for fodder. It is a tree 32 to 42 ft. in height. Its composition is as follows:—

Water	39·06	per cent.
Ash	3·60	,,
Cellulose	29·90	,,
Fat	2·55	,,
Non-nitrogenous matter	15·83	,,
Nitrogenous matter	9·06	,,
	100·00	

Acacia homalophylla (Tree.)—Leaves used for fodder:—

Water	41·03	per cent.
Ash	8·73	,,
Cellulose	22·59	,,
Fat	2·08	,,
Non-nitrogenous matter	18·26	,,
Nitrogenous matter	7·31	,,
	100·00	

Acacia Jacquemontii.—The branches are used as fodder in India.

Acacia pendula (Tree).—Known as the weeping acacia. A tree of 16 ft. 6 in. to 19 ft. 6 in. in height, which during times of drought may be used as fodder. Its value is as follows:—

Water	48·45	per cent.
Ash	4·45	,,
Cellulose	19·64	,,
Fat	1·21	,,
Non-nitrogenous matter	16·63	,,
Nitrogenous matter	9·62	,,
	100·00	

Acacia sp. (Tree).—This acacia grows in the Australian interior and provides a fodder which is eaten by cattle in times of famine:—

Water	13·45	per cent.
Ash	2·93	,,
Cellulose	30·61	,,
Fat	1·96	,,
Non-nitrogenous matter	38·18	,,
Nitrogenous matter	12·87	,,
	100·00	

In Senegal there occurs an acacia of undetermined species with pods containing a whitish pulp, which is devoured by cows, sheep, and goats.

Acacia modesta (Shrub).—In India the leaves and flowers are used as fodder. Besides these varieties, the composition of which we know, there are others which for certain reasons are distinctly valuable. Owing to their capacity for resisting drought, the fodder they produce is in much request during dry spells. For instance, in Australia, in 1902, thousands of sheep and cattle existed solely on Leguminosæ. When fed on these plants milch cows give good milk and butter. They are also fed to draught oxen.

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FIG. 51. *Acacia Salicina* (Australia).

We may mention *Acacia excelsa, A. sp., A. salicina, A. doratoxylon, A. harpophylla, A. myrtifolia, A. agrophylla*, &c.

The pods of *A. planifrons* are used as food for live stock.

Acacia Sieberiana (Tree). Sheep and goats are very fond of this plant, which is very common in Senegal and the Soudan.

Acacia Verek (Tree).—In the Soudan the leaves and fruit are used as fodder for sheep, goats, and camels.

Albizzia stipulata (Tree).—The leaves of this tree are suitable for fodder and are used as such in India.

Albizzia Lebbek (Tree).—*Albizzia Lebbek* is a large tree with deciduous leaves. When green these make an excellent fodder, and when they fall decay and enrich the soil.

The proximate composition of the leaves furnishes a proof of its value :—

Water	67·35 per cent.
Ash	2·61 ,,
Cellulose	10·18 ,,
Fat	0·80 ,,
Non-nitrogenous matter	11·62 ,,
Nitrogenous matter	7·44 ,,
	100·00

The dried leaves are not used for fodder, their high cellulose content making their consumption difficult. They serve rather to enrich the soil through the nitrogen, organic matter, and mineral elements which they contain.

	Dry leaves
Water	9·42 per cent.
Ash	8·48 ,,
Cellulose	43·90 ,,
Fat	3·68 ,,
Non-nitrogenous matter	25·40 ,,
Nitrogenous matter	9·12 ,,
	100·00

The mineral composition is as follows :—

	In 100 parts pure ash	In 100 parts leaves
Silica	3·91	0·332
Chlorine	3·53	0·300
Sulphuric acid	1·49	0·126
Phosphoric acid	2·22	0·188
Lime	41·00	3·476
Magnesia	5·58	0·473
Potash	11·58	0·982
Soda	2·59	0·219
Oxide of iron	0·84	0·071
Carbonic acid, &c.	27·26	2·313
	100·00	8·480

Albizzia Lebbek bears large flat pods about 20 cm. long by 3 cm. broad. If the dry husks were pounded up they might be used as an absorbent in food mixtures.

The pods contain hard, smooth seeds, which form an important nitrogenous food when they are crushed up.

Their nutritive value is very high : —

	In 100 parts seed
Water	12·25
Ash	3·73
Cellulose	9·87
Fat	2·97
Non-nitrogenous matter	44·06
Nitrogenous matter	27·12
	100·00
Nitrogen	4·32

The mineral composition is about the same as that of all leguminous seeds in which the potash and phosphoric acid content is relatively high. It is the proportion of phosphoric acid which most usually varies in the different varieties.

	In 100 parts pure ash	In 100 parts seed
Silica	3·73	0·139
Chlorine	1·64	0·061
Sulphuric acid	2·66	0·100
Phosphoric acid	13·53	0·504
Lime	14·50	0·541
Magnesia	7·58	0·283
Potash	35·92	1·340
Soda	1·82	0·068
Oxide of iron	0·48	0·018
Carbonic acid, &c.	18·14	0·676
	100·00	3,730

The husks give the following figures :—

Water	13·40 per cent.
Ash	6·08 ,,
Cellulose	37·50 ,,
Fat	0·70 ,,
Non-nitrogenous matter	31·82 ,,
Nitrogenous matter	10·50 ,,
	100·00

The mineral elements are :—

	In 100 parts pure ash	In 100 parts pods
Silica	1·92	0·117
Chlorine	5·27	0·320
Sulphuric acid	1·05	0·064
Phosphoric acid	5·85	0·355
Lime	19·28	1·172
Magnesia	8·55	0·520
Potash	27·03	1·643
Soda	9·15	0·556
Oxide of iron	0·42	0·025
Carbonic acid, &c.	21·48	1·308
	100·00	6·080

Judging from these results this plant seems, in areas where it is abundant and where pasture is scarce, to be of some value. Both

leaves and seeds might well be used for feeding live stock, as animals eat them readily. The seeds, like those of *Leucæna glauca,* need to be cooked.

A record of the beetles which especially attack *Albizzia Lebbek* will be useful.

An *Agrilus sp.* occurs in Mauritius which up to the present has never been described. It is a Buprestid and, according to the entomologist, M. d'Emmerez, measures 5 to 7 mm. In colour it is of a uniform purplish-brown.

The female lays her eggs under the bark of the dark wood and the larvæ burrow out the stems. The young larvæ bore passages in the stems in all directions and reduce them to powder. There is an absolute network of galleries.

Batocera rubus.—This beetle is extremely common in the East Indies and many other countries. The larvæ live in the trunk of *Albizzia Lebbek* and bore galleries. The diameter of these latter may be as much as ¾ in., a size which will give some idea of the damage these galleries may cause.

Derosphærus globicollis.—In the Comoros this beetle attacks the "Bois-noir" chiefly in spots where it has been damaged. In the same locality, according to Desruisseaux, *Albizzia Lebbek* is also attacked by *Sternotomis cornutor* and *Haploderus speniperrnis.*

This plant has other enemies: *Diaspis amygdali,* one of the Hemiptera, and *Polydesma umbricola,* one of the Lepidoptera, the larva of which undergoes its metamorphosis beneath the bark of *Albizzia Lebbek* and other trees.

Albizzia procera (Tree). In India elephants like the branches for food.

Albizzia lophanta (Tree). The leaves of this tree and those of the variety *Al. basaltica* are both used as fodder in Australia.

Desmanthus virgatus (Herb). A native of tropical America, which grows wild in the fields of Mauritius. It is an herbaceous plant of erect habit which may reach a height of 50 to 60 cm., and it provides an excellent fodder.

Samples analysed at the Station gave the following figures:

Water	68·70	per cent.
Ash	2·28	,,
Cellulose	13·21	,,
Fat	0·77	,,
Non-nitrogenous matter	11·29	,,
Nitrogenous matter	3·75	,,
	100·00	

Unfortunately it has not much foliage, the leaves being small and delicate, but it can nevertheless be used for live stock when mixed with other herbs.

Leucæna glauca (Shrub). This member of the Mimoseæ has a very wide distribution, and is particularly common in Mauritius, where it

has invaded large pieces of land. Its chief use is for fuel, and the leaves and seeds make excellent fodder. They are of no use for members of the Equidæ owing to the effect they produce on the hair structures. Horses and mules which eat them lose their hair, no such effect being produced among the Bovidæ.

These fields of *Leucæna* make very good pasture for oxen engaged in the transport of sugar-cane. The seeds are usually given them while at work, mixed with other less nitrogenous food.

They form a very rich ration:—

Water	9·59 per cent.
Ash	3·69 ,,
Cellulose	14·00 ,,
Fat	4·84 ,,
Non-nitrogenous matter	38·24 ,,
Nitrogenous matter	29·64 ,,
	100·00
Nitrogen	4·74 ,,

In his report for 1897 M. Bonâme records an experiment made in order to separate the tough coat formed of ligneous tissue from the seed. This is responsible for 50 per cent. of the weight of the seed; when decorticated the seed contains more than 50 per cent. of nitrogenous matter and 9 per cent. of fat; in other words, about 87 per cent. of the total nitrogenous matter and 90 per cent. of the total fat.

	Flour (from seeds)		Husks
Water	11·44 per cent.	...	12·58 per cent.
Ash	4·78 ,,	...	3·42 ,,
Cellulose	7·80 ,,	...	13·90 ,,
Fat	7·02 ,,	...	3·20 ,,
Non-nitrogenous matter	37·09 ,,	...	55·03 ,,
Nitrogenous matter ...	31·87 ,,	...	11·87 ,,
	100·00		100·00
Nutritive ratio	1·3		4·9

Cattle devour the leaves greedily. These leaves and branchlets form an almost exclusive food of young goats. They contain a high proportion of nitrogen and salts of potash, and are consequently in considerable request with owners who make use of dried leaves for compost.

A comparison between the leaves of *Leucæna* and goat droppings shows the similarity which exists between the two when converted into dry matter.

	In 100 parts of manure		In 100 parts of leaves
Ash	25·00	...	9·26
Nitrogen	2·48	...	2·52
Phosphoric acid	1·00	...	0·45
Potash	2·32	...	2·38

[Photo by G. Regnard.

FIG. 52.—Stems and Pods of *Albizzia Lebbek* ("Bois noir").

The following is the composition of leaves and stems, such as are eaten by animals, gathered in January, *i.e.*, in full growth :—

	In 100 parts of dry matter	In 100 parts of natural substance
Water	—	75·00
Ash	6·20	1·55
Cellulose	15·44	3·86
Fat	1·28	0·32
Non-nitrogenous matter	55·76	13·94
Nitrogenous matter	21·32	5·33
	100·00	100·00

The ash of these leaves has the following mineral content :—

	In 100 parts of pure ash	In 100 parts of green leaves	In 100 parts of dry leaves
Silica	2·00	0·031	0·124
Chlorine	5·76	0·089	0·357
Sulphuric acid	2·18	0·034	0·135
Phosphoric acid	5·10	0·079	0·316
Lime	27·60	0·428	1·711
Magnesia	6·70	0·104	0·415
Potash	24·68	0·382	1·530
Oxide of iron	0·64	0·010	0·040
Carbonic acid, &c.	25·34	0·393	1·572
	100·00	1·550	6·200

In some countries, in the Comoros for instance, where *Leucæna glauca* grows more or less indiscriminately, the leaves also serve as food for young goats (Desruisseaux).

Pithecolobium dulce.—*Pithecolobium dulce* is a tree belonging to the Leguminosæ, which grows in poor soils in warm dry spots. It may grow to a height of 5 to 6 metres and is very resistant to drought. During winter, that is to say in the dry season, it loses a portion of its leaves and becomes rather sickly in appearance, but directly the first rains commence it becomes green again, flowers, and produces pods which, through their colour, give the tree a delightful appearance. The pods are dehiscent. The pulp takes on a reddish hue, while the seeds remain black and the husk shows tones of brown and green.

The pulp of these pods has a pronouncedly sweet flavour and is greatly sought after by animals. Monkeys, in particular, feed on them when the plants occur on the sides of hills, and they are much liked by beasts generally.

The plant certainly has possibilities as regards animal feeding, but unfortunately the pods when heaped ferment very quickly and cannot even stand long transport; when freshly gathered they have a pleasant taste and are then at their best as regards food.

The seed forms 17 per cent. of the whole pod, the pulp 53 per cent., and the husk 30 per cent.

A certain amount of research has been done at the Agronomic Station at Mauritius on the value of this food.

IN 100 PARTS OF DRY MATTER.

	Seeds	Pulp	Husks
Ash	3·21	3·71	6·93
Cellulose	19·88	11·40	32·00
Fat	13·77	3·36	1·14
Sugars	7·70	51·50	5·00
Non-nitrogenous matter	34·19	15·11	43·25
Nitrogenous matter	21·25	14·92	11·68
	100·00	100·00	100·00
Nitrogen	3·40	2·34	1·87

IN 100 PARTS OF NATURAL SUBSTANCE.

	Seeds	Pulp	Husks
Water	60·00	82·60	55·70
Ash	1·28	0·65	3·07
Cellulose	7·95	1·98	14·17
Fat	5·51	0·58	0·51
Sugars	3·08	8·96	2·22
Non nitrogenous matter	13·68	2·63	19·16
Nitrogenous matter	8·50	2·60	5·17
	100·00	100·00	100·00
Nitrogen	1·36	0·41	0·83

If the fruits were dried on the spot by means of the sun and their water content reduced by 50 to 60 per cent. (in other words, the amount of moisture reduced to 30 or 35 per cent.) they might be transported from place to place without any fear of the fermentation which spoils them for feeding purposes. At the same time their nutritive value would be increased and the food rendered very useful.

	In the seed	In the pulp	In the husk	Whole fruit	In 100 parts dry matter from the whole fruit
Water	10·20	43·78	16·71	70·69	—
Ash	0·22	0·34	0·92	1·48	5·05
Cellulose	1·33	1·05	4·25	6·63	22·01
Fat	0·94	0·31	0·15	1·40	4·78
Sugars	0·52	4·75	0·67	5·94	20·26
Non-nitrogenous matter	2·34	1·39	5·75	9·48	32·35
Nitrogenous matter	1·45	1·38	1·55	4·38	14·95
	17·00	53·00	30·00	100·00	100·00
Nitrogen	0·23	0·22	0·25	0·70	2·39

The nutritive ratio is 1 : 4·1. *Pithecolobium dulce* demands no special method of cultivation. It reproduces by natural means through the seeds which spread round about. It is a very vigorous grower, requires no attention, and might occupy barren plots on plantations. The plants should be placed at least 16 ft. apart and should be protected from weeds during infancy.

Pithecolobium Saman.—This tree, a native of Brazil and Central America, has been the object of persistent study on the part of numerous observers. It has been introduced more or less into all tropical and subtropical countries, and is in much request both because of its wood and because of the ease with which it thrives in dry and barren soils.

Its cultivation has been tried in Australia and a certain value seems to have been attached to the plant. Apart from the value of its timber, *Pithecolobium*, commonly known as *guango*, produces a quantity of pods containing a sweet pulp, the flavour of which is not disagreeable, but it leaves rather a sharp and bitter taste behind. The pods, which are from 4 to 4½ in. long, have practically no importance as regards human food, but may be of considerable value as fodder for beasts, which devour them greedily. In America the fruits are of great use in the feeding of the various cattle on a farm.

The fruit of the carob tree (*Ceratonia siliqua*) has the same qualities as that of the *guango*, and this tree is of capital importance in a large portion of Algeria and South Portugal. In years of famine the fruit of the carob tree is used for human food, but it is always in considerable demand for cattle fodder and in the manufacture of alcohol. Its nutritive properties are so much esteemed that when its commercial value is not too high big companies import it into Paris for the feeding of their horses.

We have examined the composition of the pods of *Pithecolobium* and find it to be as follows:—

	In 100 parts of dry matter	In 100 parts of natural substance
Water		21·60
Ash	5·05	3·96
Cellulose	15·48	12·14
Sugar (glucose)	32·93	25·82
Non-nitrogenous matter	35·23	27·61
Nitrogenous matter	11·31	8·87
	100·00	100·00
Nitrogen	1·81	1·42

M. Boname, in his turn, gives the percentage composition of the *Pithecolobium* pod, separated from its seeds, to be as follows:

	In 100 parts of dry matter	In 100 parts of pods
Water		20·70
Ash	5·22	4·14
Cellulose	15·02	11·91
Sugar (glucose)	33·77	26·78
Non-nitrogenous matter	35·06	27·80
Nitrogenous matter	10·93	8·67
	100·00	100·00
Nitrogen	1·75	1·34

In both cases the ratio is 1 : 6·1. The nutritive value of the product is thus very high, and makes it a complete food. It can be of considerable use in the feeding of live stock, and, owing to its being easily conserved, might be kept for times when food is scarce.

The pulp of the pods, which contains more than 25 per cent. of sugar, may be used for the manufacture of alcohol.

In an experiment made in the Station laboratory an average result was obtained of 11·5 litres of absolute alcohol per 100 kilos of pods,

that is to say, about 19 litres of 60 per cent. spirit, this being the usual standard of spirit sold for consumption.

In countries where there is no necessity to keep the pods for animal fodder, a considerable quantity of spirit might be manufactured. Such spirit has an agreeable flavour, greatly resembling that of kirsch. That prepared at the Station was distributed among several people, who thought it excellent.

The wood of this tree is used, like that of *Albizzia Lebbek*, for carriage making and various other purposes, when the heart is large enough to allow of the manufacture of boards; the effect produced is charming.

The *guango* is also used as a shelter for cacao plantations, &c., and in certain countries is known as the rain tree.

Professor Harrison has published the following analysis of the seeds and pods:—

	Seeds		Pods	
	Natural	Dried at 100° C.	Natural	Dried at 100° C.
Moisture	13·46	—	20·46	—
Fat, &c.	5·15	5·95	0·56	0·71
Albuminoids	18·09	20·90	8·95	11·25
Amides	9·25	10·69	1·22	1·54
Total nitrogenous matter	27·34	31·59	10·17	12·79
Glucose	0·36	0·42	7·12	8·95
Total carbohydrates	38·20	44·15	55·35	69·59
Cellulose	12·10	13·98	11·55	14·51
Ash	3·75	4·33	1·91	2·40
Potash	—	1·52	—	1·40
Lime	—	0·22	—	0·04
Phosphoric acid	—	0·77	—	0·74

Compared with those picked and analysed in Mauritius, the above pods contain a much lower proportion of sugary matter, whilst the proportion of nitrogenous matter is about the same. Possibly it is a different variety, but it is none the less an excellent fodder. If the seeds could be pounded up and mixed with the husks it would make an animal food of the very highest order; the drawback is that the gelatinous nature of the pulp in the husks makes crushing almost impracticable. Perhaps it could be managed if the husks were suitably dried.

The following notes on the subject of the *guango* are taken from those of Mr. J. Barclay, Secretary of the Jamaican Agricultural Society:—

"The trees shed their leaves in January. The fruit ripens from March to May, and falls when it is perfectly ripe, if not previously shaken down by the wind. Horses and cattle are very fond of it; the former reject almost the whole of the seed when masticating, but cattle swallow it whole, the seeds passing out with the excrement and germinating some time afterwards.

"The fruit of the *guango* makes a rich and satisfying food. The saccharose content makes storage difficult, as it causes fermentation soon after the fruit is heaped. The only remedy is to crush and dry it

into a flour; an operation which, if it is to be effected speedily, requires a warm, dry place. A stove would be better."

Other information on the *guango* is found in the *Rapport sur les travaux aux Jardins Botaniques de la Guyane Anglaise*, which contains the following analyses of the fruit of *Saman* :—

	Fresh fruit	Fruit dried at 55° C.
Water	54·08	9·26
Glucose	10·85	21·45
Gums, pectose, &c.	8·89	17·58
Albuminoids (*a*)	7·30	10·44
Oils, fats, &c.	0·76	1·51
Starch and digestible fibre	13·73	31·07
Non-digestible cellulose	2·96	5·85
Mineral matter	1·43	2·84
	100·00	100·00
(*a*) Containing nitrogen	1·16	2·31

It is stated in this report that the constituent elements of this tree, which has been cultivated in the Colony for the last ten years, with the double object of beautifying avenues and producing shade, have about the same value as regards cattle fodder as the Oriental carob bean (*Ceratonia Siliqua*), which is extensively used for that purpose.

In the dry districts of Jamaica, where these trees abound, at Spanish Town for instance, the fruit is gathered immediately on falling and stored in barrels; during the drought, when pastures wither, they are given to cattle. Although very sweet to the taste the sugar they contain is not crystallizable.

In another report, 1896-1902, the following analyses have been given to show the composition of the seeds and of the mesocarp when fresh.

	Seeds	Mesocarp
Water	16·67	63·02
Fat	5·49	0·37
Albuminoid matter (*a*)	24·17	3·27
Glucose	1·57	13·07
Pectose, &c....	8·59	8·97
Digestible cellulose	30·77	8·92
Non-digestible cellulose	9·23	1·46
Mineral matter	3·51	0·92
	100·00	100·00
(*a*) Containing nitrogen	3·87	0·32

The mesocarp has evidently a considerable nutritive value owing to the proportion of albuminoid matters and carbohydrates it contains. The seeds, if carefully crushed, would furnish a concentrated food for cattle.

CHAPTER XI.

PLANTS PRODUCING GUMS AND RESINS.

GUMS.

Dr. Hubert Jacob de Cordemoy, in his valuable work, "Gommes, Résines d'origine exotique," divides gums into three categories:—

(1) True gums.

(2) Pseudo gums.

(3) Tano gums or kinos.

By *true gums* is meant those which are completely or for the greater part soluble in water (gum arabic).

Pseudo gums are substances which swell up in water without dissolving in it (gum tragacanth).

Kino gums are those which contain gallic acid and tannins in addition to substances which give rise to mucilaginous solutions when mixed with water.

According to Guérin Varry, the three proximate constituents of gums are: *Arabin*, completely soluble in water; *cerasin*, isomer of the foregoing, which swells up in water and remains insoluble; *bassorin*, which is likewise insoluble but swells up in water and forms a gelatinous mass.

According to Frémy, soluble gums are composed of metagummic acid, which dissolves on combination with traces of a base. Calcined gums leave a residue of mineral matters in proportions which vary with different gums. According to Groeger, gum arabic dried at 100° C. gives 3·56 per cent. of ash, composed of lime, potash, and magnesia.

Bassora gum (*Acacia leucophlœa*) is formed, according to Frémy, of an acid, gelatinous substance, which should

not be confused with metagummic acid, although to a certain extent analogous with this latter.

Several theories have been enunciated as to the formation of gum in plants; Trécul has attributed it to an over-nutrition of the cells; Beijerinck regards it as the action of certain bacteria or even of a Pyrenomycetes, *Pleospora gummipara;* Wiesner believes that this transformation is due to the action of a soluble ferment, of a diastase turning cellulose into gum and starch into dextrine. What is acknowledged and what usually happens is that the gum arises from the gelification of the cellular membranes of the stems and branches of certain plants. This substance filters through the natural, chance interstices between the tissues to the surface of the bark, where it gathers in mammillated masses of varying hardness.

Gummiferous plants usually exude their gum in the dry period which succeeds the rainy season; they occur more especially in barren and sandy countries.

M. L. Mangin, basing his view on the composition of the cell, which, in addition to cellulose, contains pectic compounds (pectose and pectic acid), considers that true gums have the same colouring reactions as these pectosic mucilages, whilst mixed gums behave like mixed mucilages in the presence of colouring reagents.

The following classification is by Cooke:—

I. True Gums or Pectosic Gums.	(*a*) True gums which are soluble. Example: Gum arabic, Gum Senegal. (*b*) True gums partially soluble. Example: Cherry-tree gum.
II. Mixed Gums or Pseudo Gums.	Gum tragacanth.
III. Tanniferous Gums or Kinos.	Gum of Butea, Pterocarpus, &c.

What should be the qualities of a gum?

Firstly, it should be as devoid of coloration as possible, soluble in water, yielding a mucilaginous liquid, spreading and adhesive; it should then be free from any admixture and devoid of any blemishes such as fragments of bark, leaves, &c.

In order to conform with trade requirements, M. de Cordemoy says it is important that gums should fulfil the following conditions:—

(1) A sample should contain a single kind only, derived from one and the same plant.

(2) The product should be of a pale colour, clear and homogeneous.

(3) The admixture of foreign substances should, as far as possible, be avoided.

(4) A good gum should be tasteless and odourless, and should form tasteless and odourless solutions, or at any rate its taste and smell should not be disagreeable.

The extraction of the gum begins at the end of the rainy season. Usually, in order to facilitate exudation, after the bark has been scraped and cleaned to prevent any fragments dirtying the product, longitudinal incisions are made in the stem. As true gums are formed in the soft tissues exterior to the ligneous zone of the stems there is no need for these incisions to be deep.

RESINS.

It is generally considered that resins are derived from the oxidation or hydration of *essences* or *essential oils*. These essential oils pour out of the cells which form them into the *secretory canal*. They are converted, according to their degree of oxidation, into *oleo-resin* if oxidation is partial and into *pure resin* if oxidation is complete. In the latter case the mass becomes solid.

Balsams are liquid resins, containing in the free state cinnamic or benzoic acid or both, and resins.

This is the broad classification, but there may be intermediate stages in which the characters are not fixed.

In contrast to gums, resins are substances partially or totally soluble in alcohol, ether, chloroform, oil of turpentine, petroleum, ether, &c.

De Cordemoy gives the following definitions of various resins: pure resins are solid bodies, most usually coloured, amorphous or crystalline, which melt at a (usually) low temperature.

Natural resins are often mixtures of several resins, varying as regards their composition and properties, but which may be isolated by the use of suitable solvents.

Pure resins are less soluble than the above in a given solvent. Natural resins are usually neutral, but some may combine with alkalis to form resin soaps.

The composition of resins is modified by heat. The oxygen of the air has far-reaching effects on some, but on others it has no action at all.

The method of extracting resins varies according to the plant, but the details are usually the same as for gums. Resins exude naturally from trees, the flow being also facilitated by incisions, or they are extracted from stems, &c., by means of special solvents.

GUM RESINS.

Gum resins are substances with a density greater than that of water and may be regarded as emulsions in water of gums, resins, essential oils, tannin, and salts.

Gum resins exude from plants in the liquid state, either spontaneously or after incisions, and solidify after an exposure to air of greater or less duration.

We will retain our classification of Papilionaceæ, Cesalpineæ, and Mimoseæ, and will give a list of the various sorts of gums.

PAPILIONACEÆ.

Adesmia balsamica.—In Chili this plant is known as *jarilla*. It produces a balsamic gum utilized in several local industries. It is a small shrub.

Astragalus heratensis.—According to Watt, a gum called *katira* or *gobina* is collected from cracks in the bark of this plant and of other varieties of the same.

Aitchison remarks that large quantities are gathered near Bezd, in Khorassan, and are exported to many parts of India, Persia, Turkestan, &c., where it is employed in making varnishes. The major portion of the gum sold in India under the name of *katira* comes from this plant. No other Indian plant is responsible for this product. This gum is of a pale colour with irregular grains which somewhat resemble crushed resin.

Astragalus.—This genus is represented by small perennial shrubs about 1 metre high. They live on dry and chalky hillocks and are not cultivated.

Several species produce the gum known as *gum tragacanth*, which is classed by de Cordemoy as a mixed gum.

Astragalus Parnassi; A. cephalonicus; A. strobiliferus; A. creticus; A. gummifer; A. cylleneus; A. verus; A. adscendens; A. microcephalus; A. pycnocladus.

According to some writers the best gum is derived from *A. Parnassi.*

All these plants demand a warm climate and may lose their commercial properties when transplanted to another climate.

The gum arises from the gelification of the cells in the pith of stems and branches and filters through the fissures, solidifying on exposure to the air, in the form of drops.

The plants are worked by making incisions in the stem after the rainy season. Two kinds of tragacanth are obtained and they are known in commerce as tragacanth *in white flakes* and tragacanth *in yellow flakes.* If during the period of drying the weather is fine the white leaves will be obtained, a kind which is very popular; if, on the other hand, the weather is rainy or the breeze strong enough to raise the dust, the gum will be turned yellow and will be only a second quality product. Care should be taken not to tap all the shrubs at once, in order to minimize the risk of a bad season.

Tragacanth in white flakes is employed in the manufacture of confectionery, in pharmacy, in the wall-paper industry, in the preparation of vellum, leathers, and high-class fabrics.

The following is the composition of gum tragacanth :—

Water	20
Pectic compounds	60
Soluble gum	8 to 10
Cellulose	3
Starch	2 to 3
Mineral matter	3
Nitrogenous bodies	Traces

It has been observed that when gum tragacanth is plunged into cold water it swells up to a considerable extent, though slowly, and eventually forms a very thick, whitish mucilage.

In acidulated water (a 1 per cent. solution) this gum becomes completely soluble after two or three hours in the water-bath. Experiments have shown that 25 grm. of this gum mixed with a litre of water give it the consistency of a thick starch, whereas 160 grm. of starch or a kilo of soluble gum would be required to give a similar result.

Butea frondosa.—This is a small tree with compound pinnate leaves having opposite leaflets, whilst the inflorescences are in simple, multiflorous clusters of orange-yellow colour.

According to Watt and Atkinson the gum produced by this plant is known as *kamarkas.*

Roxburgh, in 1874, gave a similar description to that published by J. Lépine in 1859 in his nomenclature of the products of Pondicherry at the Madras Exhibition. This ran as follows: "There flows from the bark when cut a transparent gum of a fine red, ruby colour. It is in small fragile pieces with smooth or wrinkled surface, and is partially soluble in water. If allowed to dry on the tree it turns brown and decomposes. In commerce pieces of bark are found mixed with it and adhering to it. In bulk it is of a dark red colour. It is very astringent and is capable of utilization for medicinal and commercial purposes."

Professor Solly has devoted considerable time to its study, and gives its composition as follows:—

Water	13·23
Tannin	50·70
Divers impurities	17·00
Matters only dissolving with difficulty, precipitated during evaporation and concentration	3·50
Gum, gallic acid, extractives, salts and earthy matter ...	15·00
	(Gum kino)

In the course of further research Professor Solly states that when a weight of 10 gr. (0·65 grm.) of this kino of the necessary purity is heated in a closed platinum vessel till it is red-hot the whole of the matters are burnt; there remains a residue of 0·45 of the original weight, consisting of white ash, a small portion of which dissolves in acids with effervescence. In cold water this kino swells and gives its fine red colour to the liquid.

Experiments by the same writer show that dilute acids and acid salts colour the solutions orange-yellow and cause an abundant precipitate of the same shade. A small quantity of a concentrated solution of caustic potash colours the gum solution a magnificent crimson; with an excess of potash this coloration rapidly becomes grey and an abundant precipitate is formed. Caustic soda and ammonia act like potash. Generally speaking, alkaline solutions give a rose-coloured or grey precipitate, or a shade between these. Lead acetate, like several other metallic solutions, causes the whole of the colouring matter to be precipitated. This precipitate takes various tints, but

never in any case shows the fresh and really fine original colour of the gum.

Two other species have been observed to give a similar gum to that of *Butea frondosa;* they are: *B. superba,* in which the pedicles of the orange-yellow flower are larger than those of *B. frondosa;* and *B. parviflora,* distinguished from the two others by its small whitish flowers.

Cordyla africana.—An African plant which yields gum.

Dalbergia laccifera.—This tree is used to rear the *Coccus lacca,* and in Cambodia yields from 10 to 20 kilos of lac per annum.

Ferreirea spectabilis.—A Brazilian tree, the wood of which harbours enormous quantities of a very volatile resin.

Flemingia Crahamiana.—This leguminous plant produces a red resin called *flemingin.*

Myroxylon Pereiræ.—Like the species *Myroxylon pubescens,* this is a tropical American tree, growing in the State of San Salvador. It yields the product known as Peru balsam. This is a soft, liquid product of dark brown colour, with an agreeable smell and a bitter flavour. It contains cinnamic acid and several resins.

Peru balsam is used in medicine as a slightly bitter stimulant; it is recommended for bronchitis and laryngitis. It is imported into Europe in large quantities, chiefly for perfumery. Its odour recalls that of vanilla; when added to soap it imparts its scent and causes the soap to lather. Peru balsam is used in the Catholic ritual for the preparation of holy oil.

M. Dorat, Technologist to the State of San Salvador, has made an exhaustive study of the balsam-producing tree, and we quote the following passages from his work:—

"The tree begins to produce when five years old and lives for a very long while. The collecting of the balsam begins with the dry period, in the early days of September. The bark, up to a certain height on all four sides, is beaten with the back of a hatchet until it becomes detached from the woody portion, but it is not torn or damaged. During this operation four intervening bands of bark are left, so as not to destroy the vitality of the tree.

"Several slits or incisions are then made in the beaten bark by means of a sharp instrument, and a light is applied to the openings. The balsam which flows out catches fire; it is allowed to burn for a time and the fire is then put out.

"The tree is left in this state for a fortnight and kept under close observation; at the end of this time the balsam begins to flow profusely and is caught on cotton rags stuffed in the slits. When these rags are saturated they are pressed and placed in earthen pots with boiling water, and the balsam soon floats at the surface after the manner of oil. Balsam is only extracted from the tree during four days of the week, and the average yield is 1 to 2 kilos per week.

"As soon as exudation begins to slow down, new incisions are made in the bark, a light is applied once more, and, in a fortnight's time,

extraction is begun again. The product is collected in this way until the commencement of the April rains.

"The balsam is cleaned and clarified. It is of an amber colour and turns brown as it cools; at the end of a few weeks the colour is dark brown.

"A good tree, well treated, may go on yielding for thirty years, and then, after five to six years' rest, continue yielding for several years more. The wounds take two years to heal and become covered with bark again, so that tapping may go on for several years provided the trees are allowed to rest from time to time."

We see from de Cordemoy's work that the pericarp of the fruit contains also secretory pouches filled with a purer balsam than that derived from the trunk. In the State of Salvador this goes by the name of *balsamo blanco*. It is obtained by hot compression. It is a granular, crystalline mass, golden-yellow in colour, and semi-fluid, but hardens on drying; its delicate perfume recalls that of *coumarin*. It is a rare product, almost unknown commercially.

Peru balsam, properly so called, is a thick liquid rather resembling molasses, but less viscous. In bulk it appears to be black, but in a thin layer it is of a dark orange-brown colour and perfectly transparent. Its chemical composition and its properties are absolutely analogous to those of Tolu balsam and it serves the same purposes.

We know, through a Papal bull preserved in the archives of Tzalco, that black balsam (*balsamo negro*) used to be held in such high esteem that both Pius IV, in 1562, and Pius V, in 1571, authorized the clergy to make use of this precious balsam in the consecration of holy oil (*sagrada chrisma*), and declared it to be a sacrilege to harm or destroy the trees which produced it. Copies of these bulls are said to be still in existence in Guatemala.

Myroxylon toluiferum.—This is a tree which inhabits Equatorial America. It has imparipinnate leaves, and transparent glands occur scattered about the leaflets. The pod is 6 to 8 cm. long, flattened, winged, and swollen at the extremity.

As early as the sixteenth century a Spanish doctor, Monardès, mentions the exploitation of this plant in a district near Cartagena called Tolu, hence the name of Tolu balsam. Some years before detailed knowledge of this tree was made available, *i.e.*, in 1868, Weir had described the method which the natives of the right bank of the Magdalena used in collecting the product. We will borrow the description reproduced by de Cordemoy with some notes on the composition of the balsam.

Two deep grooves are cut obliquely in the soft, yellowish-brown bark with their two ends meeting to form an acute angle. V-shaped incisions are made all round the trunk and a small calabash is fixed to receive the resinous liquid which is exuded.

From time to time a collector visits the trees accompanied by a donkey carrying a pair of large leather bottles, into which he empties the contents of the calabashes. In these leather bottles the balsam is conveyed to the export centres, where it is transferred to tin cylinders and forwarded to Europe.

Tolu balsam when newly exported is a soft brown resin, scarcely fluid, but not viscous. In the course of time it hardens and eventually becomes brittle. Seen in a thin layer it is perfectly transparent and reddish or yellowish-brown in colour. It has a very agreeable smell, which somewhat resembles that of benzoin; its taste is equally aromatic. In very old samples, those, for instance, which were imported into Europe in small calabashes during the last century, the balsam is resinified, brittle, and easily pulverized; the fracture is brilliant and crystalline. This old balsam is of a dark amber colour and has a delicate perfume.

Tolu balsam is extremely soluble in alcohol and chloroform, less soluble in ether. Its chemical composition is very complex: 7·5 per cent. of an aromatic oil with an acid reaction composed almost entirely of two esters, benzylbenzoic and benzylcinnamic ester; 12·15 per cent. of free cinnamic and benzoic acids; a resin which on saponification gives benzoic and cinnamic acids; a resinotannic alcohol, toluresinotannol; and finally, 0·05 per cent. of vanillin.

The chief export of this product is from Bolivia. In 1890 the value of the Bolivian export was 189,048 piastres (a piastre is worth about 4s.).

Pterocarpus Marsupium.—This member of the group is a tree which is found on the coast of Malabar and in the forests of Vellore, Travancore, &c. The tree is a very large one, and the inflorescences are in terminal panicles with white flowers slightly tinted with yellow. The external portion of the bark is brown, whilst the interior is yellow and dotted with red spots which mark the canals from which the blood-red liquid escapes and is collected.

In Roxburgh's work there is a note which runs somewhat as follows: "From incisions made in the bark there escapes a red liquid which hardens on exposure to the air and forms a gum resin of dark red colour and very brittle. When reduced to powder it is brown and sparkling. It burns with difficulty in the flame of a candle; without melting or swelling and without emitting any particular odour, it is reduced to a white ash. It melts in the mouth, like all true gums. Its taste is markedly but simply astringent, as much so as the gum of *Butea,* to which it bears considerable resemblance. It is rapidly and almost completely soluble in both water and alcohol. The solution is of a fine dark red colour; the alcoholic solution is perhaps the more striking, but the action of ferric salts points to there being less astringency than in the aqueous solution. This is one point of contrast with the gum of *Butea*, which is less soluble in alcohol, and under the action of ferric salts shows more astringency in an alcohol than in an aqueous solution."

This gum is known in India as Malabar kino, and to druggists as Amboyna kino. Vauquelin gives the following composition:—

Tannin and extractive matters	75
Red gum	24
Insoluble matter	1
	100

Pterocarpus indicus.—This tree yields a tanniferous gum apparently similar to that produced by *Pterocarpus Marsupium.* According to de Cordemoy, the kino of the East Indies and the Amboyna kino of the druggists are supplied by these two species.

Pterocarpus erinaceus. This member of the Papilionaceæ produces the Gambian kino. This gum contains a large amount of tannin, which colours it red.

Exudation is rarely spontaneous, but is stimulated by any damage to the tree.

Pterocarpus Draco.—This tree is a native of Guadeloupe and the East Indies, and supplies the resin or kino gum known as dragon's-blood. When the bark is cut there flow out drops of a clear, blood-red liquid, which solidify quickly. They are then collected under the name of *sanguis draconis* (dragon's-blood). Large quantities of this resin were formerly exported from Cartagena, in Spain. It is still imported into Portugal, where it is known as *sangue de drago* (dragon's-blood). It is a red resin, tasteless and odourless, used as an astringent.

Sesbania grandiflora.—A small tree which occurs in India and the Sandwich Isles; it has been introduced to the Antilles, and is known there as *Colibri vegetal.*

After the trunk has been cut there flows out a white juice slightly tinged with rose. When dry it takes on a violet tone and appears as glassy tears. When dissolved in water the liquid becomes turbid and a white resin is precipitated.

This solution turns litmus paper red. When alcohol or ether is added there is released a gum which floats at the surface with the ether. M. Cuzent has extracted two colouring principles from this product: one red, which he calls *agathin;* and the other yellow, which he calls *xanthoagathin.* The following matters are also found: arabin, a little bassorin, a resinous matter, tannin, and various salts.

CÆSALPINIEÆ.

Bauhinia retusa. Yields a gum called Semla gum, which bears considerable resemblance to gum arabic. It is eaten by the lower classes, and Roxburgh refers to it as a sweet brownish gum appearing on injured portions of the bark.

According to a report by Professor Dunstan this gum was submitted to several experts, who declared it to have but little commercial value. The tears gathered were opaque, brittle, and brown in colour. The taste is sweet and the gum feels mucilaginous to the palate, although it is not very soluble. When mixed with twice its weight of water it swells up, absorbs all the water, and forms a firm gelatinous mass. The solution gives the usual reactions of acacia gum and has only a slight reducing action on Fehling's solution; it is eight times as viscous as gum arabic. It is used in medicine.

Bauhinia purpurea.—The trunk exudes a gum of small value (Lanessan).

Bauhinia variegata.—In India this plant produces a gum known as *Semkigond.* It is brownish in colour, insoluble, and forms a product of but mediocre importance.

Cæsalpinia sepiaria.—The fruit contains a gum with strong adhesive qualities.

Copaifera copallina.—According to Baillon, Bentham and Hooker, the species has the following synonyms: *Copaifera Guibourtiana; Guibourtia copallifera.*

The natives call this large tree, which produces the West African copal, *kobo.* It occurs in the Congo, Gaboon, Sierra Leone, &c.

In nature copal appears in two forms: green copal and fossil or semi-fossil copal.

Green copal is the product of the actual copal trees. This resin flows spontaneously from every fissure in the tree in the form of whitish tears. These latter subsequently acquire a greenish or lemon yellow hue, the colour increasing in intensity with exposure to air and light, and become covered with a whitish efflorescence. The negroes make incisions in the trunk and lower branches, they then attach small clay pots, coming to change them three days later. The contents are kneaded into balls and dried in the sun.

Fossil copal is much more valuable. It is found at a depth of 50 cm. to 1 metre, and deposits are found in places where the copal tree has practically disappeared. In the Belgian Congo these deposits have been exploited for several years. Welwitsch mentions chiefly the countries which extend from the south of the Coanza, near Novo Redondo, Egito, and Benguela.

Fossil copal is sometimes found in the superficial layers, especially at the bottom of ravines excavated by rainwater.

From the commercial standpoint African copals are divided into fossil copal, which is hard, and green or tree copal, which is semi-hard. Semi-fossil copal is usually classed in one or other of these two groups, according to its state of petrifaction, but it may form an intermediate class.

Copals must be washed and sorted. Fossil copal in the natural state contains extraneous matter which is removed with a knife; it is then placed in a 1 per cent. bath of caustic soda in order to get rid of the whitish crust formed by damp or by oxidation. The same soda solution should be used for green copal if the washing in boiling water is not sufficient to remove this whitish layer.

De Cordemoy lays stress on the fact that for commercial purposes it is not sufficient to class copals according to their colour; in view of their use in the manufacture of varnishes they should be classified according to the melting point.

Distinction is made between the following principal shades: silver white, lemon yellow, amber yellow, rhubarb yellow, pale red, dark red, brown, and finally green.

According to de Cordemoy, hard copal has a density of 1·139

It burns in the flame of a candle and melts at about 340° C. without decomposing. At 360° C. it yields products of decomposition (copal oil). It is only partially soluble in alcohol, and leaves a residue of 60 to 67 per cent.; it is more soluble in ether, essential and non-volatile oils.

Copal is chiefly used in the manufacture of varnishes. It is melted and dissolved in linseed oil heated to 150° C. with essence of turpentine added.

The commercial West African copals are :--

Accra copal, usually green coloured, in small demand.

Sierra Leone copal, colour varying from yellow to tawny brown; melts at 180° to 185° C.; used for fine varnishes.

Congo copal, quality very variable; the best is very hard, transparent, almost colourless; melts at 140° to 150° C.

Angola copal, red variety in great demand, white variety less valuable.

Yellow Benguela copal, colour varying from pale to greenish yellow. In great demand in England and Holland.

Copaifera Mopane. It is from this species of Copaifera that Angola copal is derived. According to Welwitsch, it exudes a blood-coloured resin, comparable with dragon's blood.

We learn from de Cordemoy that *C. Mopane* inhabits the dry and desert lands of Southern Africa. In the west it thrives in the dry and sandy territory to the north of Cunene and in the neighbourhood of Mossamedes. Towards the east, according to Kirk, it forms on the banks of the Zambesi vast forests extending over dry and barren plains.

Detarium senegalense.—One of the gummiferous plants of Senegal. This gum is sufficiently abundant to support an industry, but up to the present no commercial use has been made of either this product or that of *Cordyla africana*.

Hymenæa verrucosa.—Produces the Madagascar copal. It is a very large tree with a straight cylindrical trunk which may, at 1 metre above the ground, measure as much as 2·50 metres in circumference. It is from 35 to 40 metres high. The natives usually prefer to exploit the hard semi-fossil copal, stores of which have accumulated at the foot of the tree; they do not beat the bark, but are content merely to cut it in order to obtain as much resin as possible.

The copal tree is very widely distributed throughout Madagascar, but it is especially abundant in the north and along the eastern slope.

The natives are acquainted with the use made of copal, and employ it to varnish furniture.

In the market it is more than likely that green copal and fossil copal are mixed. In the province of Andevorante there is a large amount of copal which fetches 50 francs per 100 kilos, and in the market of Mananjary the same amount fetches 30 francs. At Tamatave it is sold at 75 francs per 50 kilos; 4,680 kilos were exported in 1897.

In Europe first quality Madagascar copal is quoted at 4 francs per kilo.

Hymenæa Hornemanniana.—The synonym for this plant which, according to Hayne, constitutes a distinct species, is *Trachylobium Hornemannianum*. It is probably a variety of the Madagascar *Hymenæa*, and it produces the Zanzibar copal.

As in the case of the other copal trees, considerable masses of resin exude from the trunk and large branches. Captain Elton says that the copal tree is tunnelled by numerous insects, and when they reach the core the tree "seems to make an effort to check its destruction," and resin is emitted in large quantities.

In addition to the green copal, fossil copal is also found lying in the rich organic top soil which covers the subsoil of compact blue clay. The most important deposits are found on the coast, about 4 or 5 kilometres from the shore. On digging to the depth of a yard or so the pieces of copal are found covered with red sand.

These deposits are buried in a soil where copal trees were once abundant. They have since disappeared and their place has been taken by brushwood.

Hymenæa mossambicensis.—It is thought that the Mozambique copal, like that of Zanzibar, is probably only a form of *Hymenæa verrucosa*.

In Mozambique this tree is tending to disappear, and at the present day only fossil deposits are exploited. The chief of these occur in the valleys where there must once have been huge forests of this plant. These deposits are very badly worked by the negroes, who are satisfied with extracting a few ounces of copal a day.

In the Zanzibar and Mozambique trade three kinds of copal are distinguished: *Sandarusi za miti*, or green copal; *Jackass*, or semi-fossil copal; *Sandarusi*, or fossil copal.

According to Hamerton, the quantity of copal exported from Zanzibar is from 800,000 to 1,200,000 lb. per annum.

Hymenæa Courbaril.—A tree, from 25 to 30 metres high, of wide occurrence in Brazil, the West Indies, Venezuela, Guiana, &c.

It produces a resin known in commerce as semi-hard copal. The most valuable is the semi-fossil variety which has been buried for a more or less lengthy period and which arises from wounds or fissures in the roots. The oxidized superficial layer has to be removed. This resin melts between 180° and 200° C.

The living tree exudes resin which, according to Paoli, is composed of two kinds: one soluble in cold alcohol, the other only in boiling alcohol.

Heckel and Schlagdenhauffen have shown that the pericarp of the fruit contains pockets which secrete a resinous product with which the fruit is covered.

According to de Cordemoy, the characters of this resin are as follows: It is completely soluble in cold absolute alcohol. It is only partially soluble in chloroform and ether. This writer concludes from

his experiments that Courbaril resin is made up of three distinct resins: one soluble in chloroform, another in ether, and, finally, a third which dissolves in absolute alcohol. This latter also dissolves the two resins first named and is, in fact, the best solvent of this product.

These results contradict those obtained by Laurent and Paoli, who were no doubt deceived by a sample from an unauthenticated source.

According to de Cordemoy, semi-hard copal gives varnishes of paler colour than those manufactured from the hard copal, but they are less resistant; they may be used to advantage for interior varnishing work. They may also be used dissolved in Xylol instead of Canada balsam for mounting preparations for the microscope.

Hymenæa stilbocarpa.—In Brazil this plant is called *Jatoba*, and produces a copal apparently differing very little from that produced by the Courbaril species.

Tamarindus indica.—In Madagascar this plant yields a gum called *Madiro*. It occurs in somewhat bulky pieces formed by an agglomeration of tears. When examined separately these latter are clear and semi-transparent, and have a brilliant fracture.

This gum is absolutely insoluble in water. It swells up enormously in this liquid and forms a compact jelly (de Cordemoy).

Sebipira major.—In Brazil a gum withdrawn from this tree is used chiefly in medicine.

MIMOSEÆ.

Acacia arabica.—This plant supplies the gum arabic which has been familiar from the very remotest times. It is a small tree, 2 to 6 metres high, with very many branches and a brownish bark covering a reddish-brown wood.

This gum was once gathered in the lower valley of the Nile; under the Roman dominion large quantities were produced in Arabia and exported to Europe, hence the designation of gum arabic. The Arabs no longer pay much attention to their gum; what is exported to-day comes chiefly from Somaliland.

In commerce this gum, the true gum arabic, is divided into three classes, called first white, second white, and third white. It has a density of 1·355; a solution turns litmus paper red through the presence of a small quantity of bi-malate of lime; it also contains traces of potassium and calcium chloride and potassium acetate.

De Cordemoy gives the following composition :—

Arabin	79·40
Water	17·60
Saline matters and organic débris	3·00
	100·00

The Indian gum arabic also comes from this plant. This gum, which is either exuded naturally by the tree or through properly made incisions, appears in the form of irregular broken tears, cohering in

masses, each tear being about 1·5 c.m. long and varying in colour from straw yellow to reddish, almost blackish brown, according to the age of the tree.

It is almost entirely soluble in water, with which it forms a dark-coloured mucilage. Atkinson says that it is influenced by variations of climate and soil which reduce the proportion of arabin and render it inferior to that produced in North-east Africa.

The tree produces a maximum of only 2 lb. per annum. It is generally thought that the older the tree the greater the yield, but, it may also be added, the darker the colour the more inferior the quality. It has, however, been stated in a report that the old trees yield no gum. Further, the production usually varies according to the season and the more or less favourable climatic conditions; in some localities the trees give little or no gum.

The purest and palest coloured samples slightly reduce Fehling's solution; darker coloured samples are less soluble in water and leave an insoluble gelatinous residue.

Indian gum arabic is employed commercially in the printing of cotton fabrics and in any other industry where mucilage is required and this gum fulfils the necessary conditions. It enters into the composition of certain paints.

In medicine it is used as a substitute for the true gum arabic; it is also used for confectionery and enters into certain native dishes. It is inferior to that produced in Africa, and is usually a mixture of gum arabic and other gums.

Gum arabic may be said to appear in commerce in three forms :—

(1) The true gum arabic of European commerce.

(2) The gum arabic of the East Indies.

(3) The gum arabic of India.

The first is known as *Kordofan*, or *Turkish gum*. The second bears the names of *Maklai* and *Maswai*, two qualities; and the third is called *Ghati*. In India this latter is also called *Babul-ki-grond*.

Acacia arabica inhabits not only India, but also the valley of the Nile, Senegal, the Somaliland coast, and the whole of Africa as far as the Cape of Good Hope, Southern Asia, Arabia, &c.

In Senegal it appears as the red gum tree, the gum of which is of very inferior quality. Guillemin and Perrottet state that a reddish transparent gummy juice exudes from trunk and branches; it is not collected.

The price of Indian gum arabic varies in different countries. In Bilaspur 100 lb. cost Rs. 25; in Nagpur, Rs. 12; in Shapura, Rs. 20; in Bérar, where it is very rare, Rs. 50; in Kistna, Rs. 12; &c. These prices are taken from tables for 1902, and we learn from official lists published in the *Journal d'Agriculture tropicale* that Indian gums are in little demand. Further, prices may be doubled according to the origin of the gums and their condition.

In April, 1911, Ghati No. 1 was quoted at 105 francs per 100 kilos; No. 2 at 75 to 80 francs, and for Bushire there was no call. The market is thus very irregular; either there is a scarcity of these gums or they are left on the market without any demand.

The export value has been :—

	Rs.
1900–01	699,883
1902–03	454,639
1906–07	669,263

Acacia Senegal.—This is the most interesting species; it is a small tree, 5 to 7 metres high, with a leaning trunk and a very large number of branches. The leaves are alternate with two or three spines which are probably modified stipules. It grows in dry and sandy districts, especially on the right bank of the Senegal, extending over vast sandy tracts frequented by various Moorish tribes, Trarzas, Braknas, &c., who gather the gum.

The rainy season being over in October, operations are begun towards December. Owing to the tissues being swollen with water due to the humidity, the cellular membranes begin to gelatinize, and when the burning east wind starts blowing the trees dry up, the bark cracks and splits, and the gum flows through the cracks and solidifies.

In January and February the product is most abundant, the trade being then at its highest. It ceases in June.

The gum generally appears as round, white, or light-coloured, translucent masses, with an opaline fracture; the colour passes from yellowish to red, and occurs in larger masses than the Turkish gum.

The density of gum Senegal is 1·436. It is very soluble in cold water, and its ash contains oxide of iron, potassium chloride, silica, alumina, magnesia, lime, and potash.

Its composition is as follows :—

Arabin	81·10
Water	16·10
Saline matters and organic débris	2·80
	100·00

Distinction is made between two sorts of gum Senegal :—

(1) The hard gum from the lower portion of the river, from Galam or Cayor.

(2) The friable gum from the top of the river.

In all probability this latter is the product of *Acacia albida;* it resembles coarse salt, whilst the former occurs as white tears; the intermediate colours are from yellow to red.

The gum is collected by Moors and transported by caravans to various stations of Medina, Nioro, &c., where exchanges are effected. The Somali pack it in a sort of wicker basket covered with goatskin and convey it to the Gulf of Aden, more especially to Berbera.

Acacias yielding gum occur along the whole of the northern frontier of the Soudan: *Acacia Senegal* is the predominant species, then follow *A. albida* and *A. Seyal.*

As in the case of the Indian gum arabic, the value of the gum of the *Acacia Senegal* varies according to the districts whence it is taken. *Senegal* and *Kordofan* are quoted highest; after that come *Suakin, Sennaar*, and *Blue Nile.*

The export from the Somaliland coast between 1900 and 1904 was as follows :—

1900	7,718 kilos
1901	2,939 „
1902	5,302 „
1903	2,997 „
1904	350 „

In the European market gum Senegal takes the first place. The following are the export figures for 1900 to 1905 (Charabot) :—

	Weight in tons	Value in francs
1900	2,509 ...	2,336,002
1901	3,197 ...	2,910,948
1902	3,083 ...	1,647,018
1903	2,198 ...	996,773
1904	1,886 ...	1,120,881
1905	2,474 ...	1,201,795

Production varies according to the climatic conditions. The gum which occurs in the Egyptian Sudan also seems to be derived from the *Acacia Senegal.*

Acacia Catechu.—This acacia is a native of the East Indies and inhabits Coromandel. The species is better known for its product, the *catechu* or *cutch* of commerce, which is used in tanning, but the tree also exudes a gum which often appears as dark brown tears, about 1 in. in diameter. It has a sweet flavour, is soluble in water, forms a consistent, dark brown mucilage, and is not precipitated by lead acetate. It is gelatinized by basic acetate of lead, ferrous chloride, and borax; it reduces Fehling's solution.

This gum is used to adulterate gum arabic.

It is exported from the Malabar coast and from Tuticorin.

Acacia Sundra.—The gum from this acacia is similar to that of *Acacia Catechu.*

Acacia Suma.—This species is often confounded with *Acacia Sundra*, the characters of both being identical. It yields a gum which is not very well known, and which is probably used to adulterate other gums.

Acacia microbotrya.—This plant of somewhat low habit produces a large quantity of gum which, in Australia, is gathered and preserved by the aborigines. The tree yields 50 lb. of gum in a season. It is of superior quality and the natives eat it.

Acacia leiophylla.—An Australian species which produces gum. It has been introduced into Algeria, where it withstands the drought much better. It is a small tree with a very large leaf development at the summit.

Acacia capensis.—The Cape of Good Hope gum is derived from this species. It is formed of brittle and friable tears, which are almost completely soluble in water. A certain amount is exported to England.

Acacia Jacquemontii.—Some years ago the gum from this acacia was the basis of a large trade, being exported from Karachi.

In the opinion of some it is inferior to gum arabic, but it is nevertheless used in medicine, in printing cottons, and in the manufacture of paper. Messrs. Rowntree and Co., of York, say that it is the best gum for confectionery, and Watt confirms this statement. It is strongly mucilaginous, and when 10 per cent. of water is added forms a thin jelly. The solution is brownish in colour and devoid of sediment; the flavour is sweet. In Amritsar 1,750 kilos of this gum are produced annually.

Acacia tortilis.—This gum occurs in hard fragments, variously coloured and glassy in appearance, with a bitter taste and slight odour. The fragments are resinous and certain portions of their surface are covered with an opaque yellow film. The gum swells up in water without forming a mucilage and the quality is very inferior.

Acacia modesta.—This tree yields very little gum. It occurs in the form of small round tears or angular fragments.

Prebble says that it is transparent and yellowish in colour, very soluble in water, and forms a good pale-coloured mucilage. Under the action of basic acetate of lead and ferric chloride it is converted into jelly, whilst borax has no action; with neutral acetate of lead a slight precipitate or cloudiness is formed. It slightly reduces Fehling's solution. The gum is sent from Bombay to the North of India, and is classed as Amritsar gum. It is largely used in medicine.

Acacia leucophlœa.—A shrub which has been introduced into India from Asiatic Turkey. It produces the Bassora gum, which occurs in small irregular fragments, more or less twisted, white or yellowish, less transparent than the Arabian and Senegal gums, and has a slight acetic odour.

This gum is composed of bassorin united with a small quantity of arabin, and forms in water a loosely combined mucilage which tends to limit its uses. It is gelatinized by borax, whilst ether, basic acetate, and neutral acetate of lead have no action upon it. It is probably used to adulterate the best qualities of *ghati*.

Acacia Adansonii.—A shrub, 6 to 8 metres high, with erect whitish spines and yellow flowers arranged in globular fashion and situated at the axils of the leaves. It occurs fairly widely throughout the whole of the Senegal Plain, the Middle Niger, &c. It yields gum which collects in tears; the gum contains a large proportion of tannin, which gives it its red colour and renders it astringent. It is less valuable than the Verek gum.

Acacia tomentosa.—This acacia occurs in the plains of the Senegal. Like the foregoing, it is a variety of *Acacia arabica*. The gum which it produces is mixed with those of *A. Adansonii* and *A. albida* and sold as a gum of second quality.

In *Acacia tomentosa* the herbaceous portions and the ripe fruit are covered with a cottony down.

Acacia ataxacantha.—A branching shrub, very common in Senegal, 2 to 4 metres high, with short curved spines and whitish flowers in cylindrical spikes. It produces small quantities of a whitish gum.

Acacia fasciculata.—According to M. Chevalier this acacia is extremely abundant in the desert regions of Northern Africa. The whitish flowers emit an exquisite perfume.

The gum, which is fairly abundant, is unfortunately of inferior quality, being only partially soluble. In colour it varies from white to reddish, and it collects in mammillated masses.

Acacia Farnesiana.—Largely cultivated in the South of France on account of the delicate aroma of its flowers, of which great use is made in perfumery. It is a large shrub, originally a native of San Domingo, whence it has been introduced into India. In the West Indies it is called the fragrant acacia and in Réunion the yellow cassia.

It produces a fairly large quantity of gum, which, in some provinces, is collected. In Tenasserim it yields a gum which Masson says has all the properties of gum arabic; it occurs in roundish, transparent tears, which are soluble in water; according to Waring it is a first-class product.

Acacia decurrens.—In Australia, Maiden says, this shrub produces an abundance of gum during the hot season. Its colour varies from yellow to dark amber. According to the same writer, it is scarcely soluble in cold water.

After examining a sample of this gum from India, de Cordemoy concludes that when broken up into small pieces it dissolves in cold water both rapidly and completely. The solution is cloudy, but after filtration a pale yellow, clear mucilage is obtained, which is perfectly adhesive.

De Cordemoy adds that it is hard and horny, and the colour is not uniform, being pale yellow, or grey and semi-transparent in some parts, and reddish in others.

Acacia dealbata.—A native Australian tree which, according to Maiden, yields an excessively viscous gum.

It is reddish in colour, with a light-coloured fracture, and may be collected in fairly large quantities.

Heckel and Schlagdenhauffen have analysed it, and found it completely soluble in water:—

Hygroscopic water	13·716
Non-volatile salts	2·173
Tannin	0·230
Gum arabic	83·881
	100·000

Samples from Réunion, where this acacia has been acclimatized, took the form of large, irregularly spherical tears, dark red in colour, with a dull fracture. This gum is only partially soluble in water and contains from 8 to 10 per cent. of insoluble gum. De Cordemoy

considers this is another example of how climate can influence the composition and properties of gums.

Acacia pycnantha.—An Australian acacia cultivated in Algeria and introduced into New Caledonia. It yields a gum of inferior quality. The gum is entirely soluble in cold water, but the mucilage is thin and has no adhesive properties whatsoever.

Acacia homalophylla.—De Cordemoy, in his book "Gommes et Résines," says this acacia yields throughout the summer a large quantity of gum with a striking resemblance to pine resin. It is of a lightish colour and has a brilliant conchoidal fracture. It is soluble in water, makes a pretty, pale-coloured solution, and is perfectly adhesive.

Acacia pendula.—The gum obtained from this plant is completely soluble in cold water, and gives a light-coloured or rather darker mucilage according to its age. Large quantities are exported from Australia to England.

Acacia horrida.—In Southern Africa this acacia is exploited by Germans and produces a fair quantity of good quality gum.

Other gummiferous acacias to be recorded are: In Senegal, *Acacia astringens*, *A. Neboueb;* in Mauritania, *A. gummifera;* in East Africa, *A. Seyal*, *A. Ehrenbergii;* in Australia, *A. melanoxylon*, *A. mollissima*, *A. sophoræ*, &c.

Adenanthera pavonina.—This tree produces the gum known as *madatia.*

Albizzia Lebbek.—A large tree, of which the common name in Mauritius, Réunion, and the West Indies is *Bois noir* (black wood). It exudes a gum which Roxburgh records as being of great purity, and in India it is also regarded as a high-class product.

Baden-Powell says that it is partially soluble in water and swells up in this liquid, tending to form a jelly.

De Cordemoy has examined samples from Réunion and is of the same opinion. The gum is either reddish and opaque, or pale yellow, limpid, and transparent; it occurs in mammillated fragments, and sometimes in long adhering tears.

When the product is dried for an hour at 120° C. it loses 6·05 per cent. of hygroscopic water; 20 grm. of gum dried in this way are immersed in 400 grm. of distilled water. It then swells up slowly. In 24 hours' time it has considerably increased in volume and forms a reddish translucent mass of granular appearance (de Cordemoy). It can be rendered soluble either by the action of heat in presence of a small quantity of potash, or by the action of heat under pressure. After these modifications it becomes adhesive.

Albizzia procera.—Both in India and Australia this gum may be gathered in abundance. It is more or less dark in colour, so that pieces are selected in which the dark tint is only superficial. It swells up in water, and is only partially soluble.

[Photo by G. Réhaut.

FIG. 53.—*Acacia melanoxylon.* (Leaves and phyllodes.)

Maiden says that this gum differs from the insoluble gum of the acacia in that the latter swells up in water in a more coherent manner, while the former forms curdy masses.

Albizzia Sassa.—This tree grows at Nossi-Bé and Lamandra. The trunk exudes a gum called *sassa*, the properties of which resemble those of gum Bassora.

Albizzia stipulata.—Gum is obtained from all the albizzias by making incisions in the stems, and though not much used as a whole, that of *Albizzia stipulata* is employed in the manufacture of paper in Nepal (India).

Algarobia glandulosa.—This small tree occurs in the West of Texas and, according to Captain Marcy, is found in abundance on the banks of the Colorado. It is fairly common in several parts of the world.

It exudes spontaneously a gum called *mezqueet;* incisions facilitate and increase production. In certain months, July and August, it can be collected in large quantities. Its colour varies from pale yellow to dark amber.

M. Shumard gives its composition, and states that it contains 84·96 per cent. of arabin. It is very soluble in water and forms an adhesive mucilage.

Calliandra portoricensis.—The trunk exudes a peculiar gum known in Brazil as *copaltic.*

Dicrostachys cinerea.—This plant yields an astringent gum (Lanessan).

Parkia biglandulosa.—This gum occurs in flattened or roundish tears; the colour is reddish brown; it is insoluble in water and changes in this liquid to a brown jelly. It has practicaly no value.

Piptadenia rigida.—This leguminous plant resembles an acacia and produces a gum analogous to gum arabic, known in commerce as gum angico. It is largely used in Brazil, where it is regarded as being superior to gum arabic. The plant is very common in that country and is very productive.

Xylia dolabriformis.—The trunk of this tree exudes a red gum resin.

CHAPTER XII.

LEGUMINOSÆ PRODUCING TANNING MATTERS AND DYES.

AMONG the Leguminosæ an important part is played by plants which produce tanning matters and dyes.

It is generally the bark of these plants which is used in the preparation of tan, a powder from which is derived the tannin used in preparing hides, in the manufacture of ink, the tanification of wines, &c.

Colouring matters are extracted from the flowers, leaves, wood, or bark; in other words, taking the various species generally, from every portion of the plant.

Numerous species of acacia and cassia yield tanniferous barks of excellent quality. They are easily suited as regards the nature of the ground, thriving best, however, in a light soil with a clay subsoil. They are usually grown in rows at intervals of 12 ft. This interval may vary with the variety or according to the richness of the soil, but in no case should the trees be planted too closely or they will yield a thinner and consequently a less valuable bark.

In order to accelerate the germination of the seeds it is advisable either to immerse them in concentrated sulphuric acid, subsequently washing them in running water, or to allow them to soak in water or even in boiling water. At the Agronomic Station at Réduit, where a few experiments have been made by M. Bonâme, the best results have been obtained with boiling water. The water is poured over the seeds and allowed to cool of its own accord for forty-eight hours. In this way seeds have been made to germinate in ten to twelve days. This method is only recommended,

however, provided sowing is carried out at the commencement of the rains, otherwise, during dry spells, the seed, which is already swollen up by the water, will dry up and die.

They may be sown in beds and transplanted when the young plants are from 25 to 30 cm. high.

Exploitation of the trees may be begun when they are seven or eight years old, though their full development is only reached at the age of ten; at this period the yield is at its maximum.

In Australia stripping is carried out from September to December, but in Natal it is done at any time. Stripping takes place whilst the plant is full of sap and still standing. There are two methods of cutting employed: one consists in cutting the tree at a point 4 ft. above the ground and in removing the bark in ribbons down to the ground; the other in making an incision at the base and removing the bark in strips as far as the lowest branches.

These strips are dried in the sun, or even by artificial means, in order to obviate all dampness, the occurrence of which would change the colour of the strips and cause them to be attacked by mould.

The strips are cut into pieces 2 in. long by 1 in. wide and packed in sacks.

After the trees have been stripped they are felled and used for fuel or other purposes; it has even been thought of converting them into paper pulp.

After this operation the plantation is abandoned and left to grow up again of its own accord; it then only needs clearing to prevent the trees from becoming too crowded. In some countries the cost of clearing is estimated to be as expensive as starting another plantation on a new piece of land.

The production of a tree varies according to the number of trees per hectare. The farther apart the trees the greater their development and the greater their production. The

spacing of the lines which is usually recommended is 12 ft. by 6 ft., thus making about twelve to fourteen hundred trees per hectare.

All these data may be found in the publications of the countries where these plantations occur; unfortunately the results obtained so far vary considerably and no positive conclusion has been reached.

In the *Tropical Agriculturist* for September, 1908, Mr. Gisborne relates that thirty trees, eight years old, growing under good conditions, yielded a ton of dry bark. He reckons that, with 150 trees, at the end of eight years the hectare would produce 12 tons of bark at £6 per ton, say £72. Taking lands which are rented for pasture in Australia at 2s. per acre, this would be an extremely good price, notwithstanding the 50 per cent. that must be subtracted for the total expenses.

In the *Tropical Agriculturist* for June, 1909, Mr. Kellow gives another estimate of the yield per acre after eight years' time:—

	Rs.
Expenses for seven years	180
,, the eighth year	730
	910
Crop: 15 tons of bark at Rs. 90	1,350
1,200 trees for fuel at Rs. 0·5	600
	1,950

Profit = Rs. 1,040, or Rs. 130 per annum.

M. Bonâme, who has summarized these different publications in his annual report for 1910, adds that this last estimate appears to be a very high one, and regrets not having been able to obtain more exact figures.

Large plantations have been made in Natal (50,000 acres), in India, at the Cape, and in German East Africa, &c.

We shall give a note on all the best-known leguminous plants from which tannin is extracted. It is evident that the analyses that have been made are by no means absolute, as

the figures for the same species may vary within fairly wide limits.

This is no doubt the result of vegetative and climatic conditions, which may be more favourable in one locality than in another: the age of the plant is also an important factor in this variation; similarly the season in which the crop is taken.

In the case of the fruit the degree of maturity will cause the proportion of tannin to vary.

It is not always the same parts of the different plants that give the highest percentages. In some it is the leaves, in others the bark, and in others again the wood. Analysis is thus indispensable in order that the planter may determine what to do with the various trees.

The sappy bark from the oldest trees should be removed first, and young pods will yield more tannin than those which are nearly ripe.

The nature of the tannin from the bark and from the pods of the same tree may vary, and similarly the tannins contained in all Leguminosae may not be equally efficacious. This no doubt tends to show that their compositions and combinations are not identical, and would explain the shortcomings of certain tans.

The best plan will be to make practical trials in order to determine a choice of species. This is all the more evident when it is seen that the barks of certain plants of the same family give negative results in one country and markedly good results in another.

According to "Watt's Dictionary of Economic Products," the tannin from the pods of *Acacia arabica* consists chiefly of gallotannic acid combined with saccharose and other inert substances, whilst that derived from the bark is of a different nature.

In some countries trees are exploited which have never been cultivated and which are found either in forests or among vegetation which has invaded large tracts of land.

This is the case in India, but of recent years a start has been made on regular plantations.

All these data as to the variation in the yield and quality are equally applicable to plants which produce dyes. A special note is appended on each of the principal species.

PAPILIONACEÆ.

Baphia laurifolia (Tree).– Both bark and wood contain tannin and are used in dyeing.

Baphia nitida (Shrub). -In cold water the wood yields a dye of a fairly bright red.

Baptisia tinctoria (Herb).- In U.S.A. this plant is used as a substitute for indigo. A blue colouring matter is extracted from the leaves.

Butea frondosa (Tree).—This tree produces an astringent gum, and the bark contains a large amount of tannin, but it does not appear to be used in the preparation of leather. In the French possessions in India the bark is used for dyeing blue and for tanning. The flowers yield a yellow dye of good quality. Natives make use of the gum in order to precipitate and purify indigo-blue.

Clitoria Ternatea (Liane).—In Martinique the flowers are used for obtaining a blue dye.

Cylista scariosa (Herb).—The root of this plant is astringent and contains about 10 per cent. of tannin.

Dalbergia latifolia (Tree).—A decoction of the bark of this tree is exported from Coorg (India) for tanning purposes. It is very astringent.

Desmodium sp. (Undershrub).—The leaves of this plant contain a blue colouring matter similar to that of the indigo-tree. After treatment with lime the natives use it to dye their stuffs.

Flemingia Crahamiana (Shrub).—Produces a red colouring matter of considerable value.

Indigofera tinctoria (Shrub). The plants belonging to this genus of Leguminosæ yield the blue colouring matter known as indigo.

The chief species is *Indigofera tinctoria*, a native of the East Indies. The cultivation of the plant and the extraction of the colouring matter vary in different countries, but the blue matter as it occurs in commerce does not exist by any means in the same form in the leaves.

The leaves contain a colourless matter called *indican*. After fermentation this matter is converted into *indigotin*, which is soluble, after reduction, in an alkaline wash, and is then in the state of indigo white. Vigorous churning of the liquids causes the indigo white to become

oxidized by contact with the atmosphere, yielding *indigotin*, the blue colouring matter. (See A. Haller, "L'indigo naturel et l'indigo artificiel.")

Colouring matter may be obtained from other indigo plants, such as *Indigofera pseudo-tinctoria, I. disperma, I. hirsuta, I. angustifolia, I. trifoliata, I. sericea, I. cytisoïdes, I. glabra, I. glauca, I. Anil*, &c. These are less cultivated.

Indigofera Anil is cultivated in Java and the Sunda Isles; *I. tinctoria* is very common in India; the Guatemala indigo plant, which has been introduced into Java, is *I. oligosperma*, and that of Natal is *I. leptostachya*. *I. erecta* is also found in Java and Natal.

The colouring matter of the indigo plant was known in the Middle Ages. Marco Polo gave a description of it, although a very short one, in 1298. The Russian traveller Athanasius Nikitin spoke in 1468 of Cambay, where the indigo plant grows. Garcia de Orta (1563) gives a summary of the cultivation and manufacture of indigo. In Père Labat's "Voyage aux Isles de l'Amérique" occurs a long and interesting account of the manufacture of indigo. Similarly, during the last eight centuries, this colouring matter has attracted the attention of numerous authors.

The use of indigo dates back a considerable time. Cossigny quotes an extract from the "Memoirs of the Société d'Agriculture de Paris" for the year 1789, in which the citizen Moreau de St. Méry states that in Dondon and many other parts of the colony the indigo plantations had been abandoned, and that a similar state of affairs was threatening Bourbon.

At this period the consumption of indigo in France had increased owing to the clothing of the Garde-nationale and the Republican troops in uniforms of this colour, and also because the colour was fashionable.

The chief centres of indigo production are British India, the Philippines, Siam, China, Japan, Natal, New Granada, Venezuela, Mexico, &c.

The value of the total production of indigo is from about £2,500,000 to £3,000,000 per annum.

In 1878 von Boeyer first solved the problem of artificial indigotin. The production has recently been put on a more economic footing. Two methods are in use: one has naphthalene as its basis, and the other toluene, both extracted from coal tar.

The indigo plant needs to be cultivated under good conditions. The date of sowing varies in different countries, the seeds usually being planted at the beginning of the winter season. By using selective methods plants with large yields have been obtained. In India, and also other countries, attention has only been directed to the most paying varieties.

Indigofera tinctoria is a native of Gujerat and has become acclimatized in all warm countries; but, as has already been remarked, in every country there is one particular variety which takes precedence over the remainder owing to its cultural requirements and to its better yield.

Pterocarpus santalinus (Tree).—A fine, large tree growing in Ceylon, India, the West Coast of Africa, Japan, &c.

The wood is hard, and the colour of the exterior is dark red, with a lighter shade inside.

The red colouring principle is *santalin;* the wood is used either as a powder or in chips, and serves for dyeing stuffs.

Pterocarpus angolensis (Tree).—Common in Senegal, the Gaboon coast, &c. Is the source of the red sandal-wood of Africa. It is said to be richer in colouring matter than the foregoing, but its colorations are less stable. It occurs in commerce in the form of a coarse powder. The bark is used in tanning.

Pterocarpus Marsupium (Tree).—The thick substance which exudes from this tree is exceedingly astringent and is largely used in medicine. The bark is used for tanning and is very rich in kinotannic acid. The extracts obtained from this tree have been recommended for tanning on a large scale.

Sophora japonica (Tree).—In China the flowers are dried and form the *Wai-fa* or *Wai-hwa* used as a yellow dye.

CÆSALPINIEÆ.

Bauhinia purpurea (Tree).—This tree yields a bark which is used both in tanning and dyeing.

Bauhinia racemosa (Liane).—The bark is used for dyeing.

Bauhinia variegata (Tree).—The bark is used for tanning and dyeing.

Cassia auriculata (Tree).—The bark of this tree, known as *tarwar* in the Central Provinces, and as *tangedu* in the South of India, is one of the best native tans known.

The following are analyses of both young and ripe barks from Mysore:

	Young	Ripe
Tannin	11·92 ...	20·12
Extract	22·35 ..	29·00
Ash	4·15 ...	6·40
Moisture	7·26 ...	7·80

A sample of this bark examined at Dehra Dun contained 15·5 per cent. of tannin, with a high proportion of soluble non-tannins. The colour of the infusion was very light.

Cassia fistula (Tree).—In Bengal, Southern India, and the North-west Provinces, the bark of this tree is used in tanning. The proportion of tannin is from 9·5 to 12·9 per cent., but it is usually associated to a large extent with non-tanning substances.

Cassia chamæcrista (Tree).—In Guadeloupe the bark of this tree is used in dyeing.

Cassia marginata (Tree).—The bark contains 6·1 per cent. of tannin and is used in Mysore (India).

Cassia siamea (Tree).—A sample of the bark, which was sent to Mysore as tanning material, contained 4·1 per cent. of tannin.

Cassia Tora (Tree).—This tree is cultivated for its seeds, which the dyers of blue cloth in Pondicherry use as a mordant.

Cæsalpinia coriaria (Tree).—The plant known as *dividivi* was introduced into India by Dr. W. Hamilton in 1834. It is a native of America and the West Indies.

It has been cultivated in a number of localities with varying success, and the pods have occasionally been exported to London. The South American pods usually contain 30 to 50 per cent. of tanning matter. For tanning purposes the Indian *dividivi* is regarded as inferior to that of America, and Professor Dunstan confirms this opinion. Possibly samples from other provinces give better results According to Thorpe, in order to exploit the *dividivi* in India with success, it is necessary to incorporate some substance which prevents the usual fermentation taking place and spoiling the tanning process.

The fruit contains a yellowish pulp used in dyeing.

Cæsalpinia digyna (Tree).—This plant grows wild in several Indian Provinces. Commercial samples have given 33 per cent. of tannin. According to experiments made by Professor Dunstan in 1899, pods stripped of their seeds contained 50 per cent. of tanning matters, and in a sample from Assam the proportion was about 60 per cent. Consequently the pods are richer than those of the American *dividivi*, and an aqueous solution does not seem to be subject to the fermentation which is the cause of so much trouble in that variety.

Appended are analyses of three samples of crushed husks from Bombay, Burmah, and Assam :—

	1	2	3
Moisture	11·07	10·93	11·40
Tanning matter	53·82	53·86	59·89
Total soluble matter	61·95	62·83	65·80
Non-tanning matter	14·08	14·86	12·73
Ash	2·28	3·76	1·84

Cæsalpinia brevifolia (Tree).—Mr. N. Evans finds a large quantity of tannin in these pods; the fibrous portions giving 11·0 per cent., and the gummy or resinous portion 66·9 per cent.

M. Zoelfell has examined these tannins and decided that they are a mixture of two bodies. The first, or smaller portion, is a glucoside of gallic acid, and the second is ellagic acid with the formula $C_{11}H_{10}O_{10}$.

Cæsalpinia crista (Tree).—A fine tree inhabiting the Brazilian and Jamaican forests. The reddish-brown wood turns water a fine red colour, giving it a sugary flavour and a slightly aromatic odour.

Cæsalpinia echinata (Tree). Occurs in the forest of Sainte Marthe, in New Grenada. Although less rich than the foregoing, it is nevertheless considered one of the good woods for red dyes. It is known as Brazilian wood or Pernambuco wood. The dyeing matter is *bresilin*.

Cæsalpinia brasiliensis (Tree.)—The wood of this tree is hard, compact, and takes a polish. It is devoid of sap-wood, and when freshly cut the colour of the wood is brick-red. The older the tree the larger the amount of colouring principle.

Cæsalpinia Sappan (Climbing Shrub).—This plant grows in India, China, Japan, Brazil, and to a certain extent in every part of the Tropics where it has been introduced. It is a hard wood, dark red in colour externally, and brighter internally. It is the palest of the red woods; it is chiefly used in India for dyeing cotton fabrics. If a decoction of this wood be combined with ammonia a fine red colour is obtained; with salts of iron it gives black, and with sulphate of copper, alum, or cream of tartar a very lasting blue.

Cæsalpinia vesicaria (Tree).—This is the red wood of Jamaica, which also grows in Guiana, the east of Cuba, &c. The colour is brown with darker transverse veins. Both this variety and the variety *Cæsalpinia tinctoria* offer resources to the dyer.

Cæsalpinia sp. (Tree).—A Colombian tree exported in blocks known as *bois de terre ferme*. The interior of the wood is golden yellow with concentric zones of reddish-yellow which become darker as they approach the centre from the periphery.

Cæsalpinia sepiaria (Tree).—The wood is rich in colouring matter and is used in Gaudeloupe for dyeing red.

Hæmatoxylon campechianum (Tree).—Campeachy wood derives its name from Campeachy Bay. The tree is a native of Mexico. South America, Jamaica, and especially the West Indies produce a considerable quantity. Nowadays, this plant may be said to occur throughout the Tropics.

Hæmatoxylon campechianum contains a colouring matter with a definite composition, hæmatin, or hæmatoxylin. ($C_{16}H_{14}O_6$.)

There is no colouring matter contained in the bark, and the sap-wood, which is of no value, is separated from the heart-wood. When the wood is freshly cut the colour is reddish-yellow; in contact with the atmosphere it turns blackish-red.

Several samples of logwood (heart-wood and sap wood) have been analysed at the Mauritius Agronomic Station, and the tannin content has been found to be 10·3 per cent.

Logwood is one of those natural products which have survived the competition of artificial colouring matters, and not a few factories in France are occupied in preparing the extract.

The hæmatoxylin which is contained in the duramen of the Campeachy tree is colourless, but becomes oxidized on exposure to the air, forming hæmatin. The hæmatin occurs in the wood, partly in the free state, partly in the state of glucoside, that is to say, partly in the state of a product which is hydrolyzed into glucose and another special substance, which in this case is hæmatin. The decomposition of the glucoside has therefore to be provoked, and this is brought about by cutting up the wood in such a way as to allow of spontaneous fermentation.

Considerable use is made of this colouring matter in dyeing. The chief export countries are Haiti, the English possessions in America, Mexico, the Argentine, Guatemala, Martinique, Gaudeloupe, &c.

The wood is cut into logs and shipped to Europe.

Peltophorum Linnæi (Tree).—A Brazilian tree, the wood of which contains an orange-coloured dye-stuff. The wood is known in commerce as *Brasilette.*

Saraca indica (Tree).—The bark is used in medicine and appears to be simply astringent. A sample from Bombay contained 5·7 of tannin which, in association with salts of iron, gave a greenish-coloured dye-stuff.

Vouapa Simira (Tree).—A dye-stuff is extracted from this plant in Guiana.

MIMOSEÆ.

Acacia arabica (Tree).—The bark is very astringent, and is one of the most commonly used tanning substances in India. Dr. Leather has obtained 16·4 per cent. of tannin, and Mr. Hooper 16·7 per cent., from two samples from different localities.

The husks give from 5 to 20 per cent. of tannin, according to their state of maturity; the content is highest in the younger pods.

Their composition is as follows:—

	Bark	Pods
Tanning matter	30·0	22·8
Soluble non-tanning substances ...	24·4	34·1
Insoluble ,, ,, ...	6·2	8·4
Water	39·4	34·7
	100·0	100·0

The pods are reduced to powder while still green, and in combination with salts of iron are used in the manufacture of ink.

As regards tanning, experiments have shown these extracts to be too deeply coloured for the European market, and their proportions of soluble non-tanning substances are also too high, being from 24·4 to 34·1 per cent., while those of commercial extracts range from 2·4 to 13·7 per cent.

The pods of this acacia yield the Indian *bablah*, which is used for dyeing. These pods are blackish-grey in colour and covered with a slight, whitish, extremely adherent down.

Acacia concinna (Tree). The bark of this acacia is used in the south of India for tanning and dyeing.

Acacia pycnantha (Tree).—An Australian variety the bark of which contains 33·8 per cent. of tannin. According to the *Tropical Agriculturist*, the proportion may be as high as 40·2 and 40·5 per cent.; non-tannins 9·0 to 9·4 per cent.; insoluble matter 29·6 to 39·6 per cent. The bark is called *golden wattle*, and is largely used in tanning.

Acacia dealbata (Tree).—We make the average content of tannin to be 13 to 14 per cent. with extremes of 12·2 to 17·8 per cent.; non-tannins 4·3 per cent.; insoluble matter 71·9 per cent. (*Silver wattle.*)

Acacia decurrens (Tree).—The proportion of tannin in the bark may vary from 36·1 to 41·4 per cent.; non-tannins 4·4 to 9·1 per cent.; insoluble matter 39·2 to 46·2 per cent. (*Black wattle.*) Bark largely used for tanning.

Acacia melanoxylon (Tree).—The bark gives 28·6 per cent. of tannin, with limits of 20 to 32 per cent. A very fine tree, the wood of which is used for fuel. The bark is in large demand for tanning purposes.

Acacia Farnesiana (Tree).—A sample of bark taken from Southern India gave 2·8 per cent. of tannin, extracted by means of warm water. This acacia occurs throughout the Tropics and is largely grown in France for its flowers, "fleurs de cassie." It is said that at Dacca the bark is mixed with salts of iron in the manufacture of a deep black dye. In new Caledonia and Guiana the fruits are used for dyeing purposes.

Acacia Intsia (Tree).—The bark or fresh leaves are used in dyeing as mordants.

Acacia pennata (Tree).—The bark contains 8·8 per cent. of tannin. With salts of iron it yields a black colouring matter. It is an article of commerce, being exported from Concan and used in Bombay for tanning fishing nets.

Acacia Suma (Tree).—Fairly common in Bengal and Southern India. In damp soils it seems to be of luxuriant growth. It yields a white bark, which is used in the tanning industry both in Africa and in India.

Acacia penninervis (Tree).—The bark is rich in tannin and contains 37·7 per cent. of that substance; 5·2 per cent. of non-tannins; 46·1 per cent. of insoluble matter.

Acacia Adansonii (Tree), **Acacia nilotica** (Tree), **Acacia Sing** (Tree). All give pods used in dyeing and tanning.

Acacia leiophylla (Tree).—This species is very much exploited in Australia for its bark, which contains as much as 30 per cent. of tannin.

Acacia leucophlœa (Tree).—The bark of this acacia may yield a tan of a quality equal to that of *Acacia arabica*. It contains 20·8 per cent. of tannin (sample from Mysore). Another sample, from Dehra Dun, only gave 9·33 per cent., with a high proportion of soluble non-tanning substances. This plant is also used in dyeing; the leaves are used for dyeing black.

Acacia Catechu (Tree).—*Acacia Catechu* is the tree which yields the product known as *catechu* or *cutch*. It has been known for several centuries, for European writers, such as Barbosa (1516), speak of the *cacho* exported from Cambay to Malacca. Garcia de Orta gave a complete account of the plant and of the manufacture of the extract in 1574, but it was only towards the end of the 17th century that *A. Catechu* attracted European attention.

There are three forms of catechu:—

(1) The black catechu, chiefly used for industrial purposes.

(2) The pale Indian catechu, a crystalline substance employed in medicine

(3) *Keersal*, a crystalline substance which has been found deposited in the wood.

The black catechu is prepared in the following manner: The wood is cut up into pieces and allowed to boil for twelve hours; the wood is then removed and the liquid evaporated till it is of the consistency of syrup, it is then poured into wooden frames resembling brick moulds. After cooling, the blocks are cut into pieces weighing from 36 lb. to 44 lb. A ton of wood is usually reckoned to give 250 lb. to 300 lb. of black catechu.

This substance is chiefly used in the tanning and dyeing industries.

Pale catechu is prepared in a different way. In the north of India the method is as follows: A concentrated decoction of the wood is made and twigs are added till the cooling is complete. The twigs are then withdrawn and the crystalline substance which has been deposited is removed; it is then pressed into large irregular cubes. It is used in medicine as an astringent and the natives eat it.

Keersal is a crystalline substance occasionally found in the wood. Dr. Dymock says that the *Keersal* or *catechuic acid* occurs in small irregular fragments resembling small pieces of very pale catechu mixed with shavings of reddish wood. It occurs in the forest trees of Bariya and Gujerat, and is used as a remedy for coughs, for which it is very efficacious.

The three varieties *Acacia Catechu*, *A. Sundra*, *A. catechuoïdes* all produce it.

These acacias occur in India, especially in Burma, Ceylon, and on the West Coast of Africa. In Mysore, Bengal, and Gujerat catechu is also extracted from *Acacia Suma.*

India exports on an average 10,000 tons of catechu per annum, chiefly to England. The French colonies do not produce any.

We append some figures, the averages of thirty-one analyses :--

	Burma Catechu	Indian Catechu
Water...	11·4	9·7 to 14·1
Tannin	44·3	15·2 „ 46·0
Catechin	5·0	1·7 „ 40·8
Soluble non-tannin	34·0	3·2 „ 36·7
Insoluble organic matter...	2·4	1·1 „ 20·4
Ash	2·9	1·5 „ 38·3
	100·0	

The difference between the extremes is thus large enough to justify our saying that the quality depends on the locality where the catechu is manufactured. The figures for the Indian catechu are taken from twenty-six analyses of samples from different localities.

Acacia sarmentosa (Shrub).—The bark of the fruit may be used for dyeing black and for tanning.

Acacia ruguta (Tree).—The bark is astringent, and is used in dyeing and tanning.

Acacia Sundra (Tree).—Shavings boiled in water yield a dyestuff of a beautiful purple black.

Acacia Cebil (Tree).—Owing to the quantity and excellent quality of the tannin contained in the bark, this tree is one of the most useful of its kind in America.

Adenanthera pavonina (Tree).—The wood is dried, pulverized and used as a dyestuff. It forms the red paste called *tilak* which is used by the Brahmins to dye their hair.

Albizzia Lebbek (Tree).—The bark is used in tanning hides. A sample from Dehra Dun (India) contained 11·33 per cent. of tannin and 4·3 per cent. of soluble non-tannin. The colour of the extract was very deep. An analysis of this bark in Mauritius only gave 3·8 per cent. of tannin.

Albizzia procera (Tree).—The bark is sometimes used as a tan.

Entada scandens (Climbing Shrub).—The bark is used for tanning hides. Another variety, *Entada africana*, growing in Africa, serves the same purpose.

Inga Burgoni (Tree).—The bark of this species, and also that of *Inga marginata*, forms a tan.

Mimosa pudica (Shrub).—The roots of the *sensitive plant* contain about 10 per cent. of tannin.

Pithecolobium Avaremotemo (Tree).—In Brazil the pods of this plant are used in dyeing, and the astringent bark in tanning. The pods shrivel into little rolls and are impregnated with a gummy juice. This gum shows a brown outer layer with cracks covered with a white coat which is only present in places; and a reddish-brown internal layer with longitudinal striations.

Pithecolobium parvifolium (Tree).—This plant goes by the name of *algarovilla*. The fruits contain a fine orange-red dyestuff which is obtained by crushing the pulp (Lanessan.)

Pithecolobium Unguis-cati (Tree).—The pods contain a yellow colouring matter used in dyeing. The pericarp is astringent and rich in tannin.

Prosopis dulcis (Tree).—As much as 20 and 21 per cent. of tannin is obtained from the bark, leaves, and pods of this tree.

Prosopis spicigera (Tree).—In the Punjab the bark is used as tan.

Xylia dolabriformis (Tree).—In September, 1896, the *Indian Forester* drew attention to the possibilities offered by the wood of this tree.

An experimental extraction was made in 1897, and as a result 2 tons of shavings gave 97 lb. and 2 tons of sawdust gave 58 lb. of extract.

According to Professor Procter, the composition of these extracts was as follows:—

Tannin absorbed by the hide	32·0 per cent.
Soluble non-tannins	4·9 ,,
Insoluble non-tannins	5·0 ,,
Water...	58·1 ,,
	100·0

Professor Procter concluded that this extract was capable of providing a tanning matter of considerable value.

CHAPTER XIII.

LEGUMINOSÆ YIELDING WOOD FOR BUILDING, CABINET-MAKING, ETC.

THERE is a large demand in commerce for the wood of the Leguminosæ. The qualities of some kinds are such as to give them a considerable value.

The wood of many of these plants possesses all the requisite qualities: hardness, beauty of grain, variety of colour, and agreeable odour, and consequently such woods are in great demand for the manufacture of high-class furniture.

The hardness of some species is so great as to render the working even of the sap-wood difficult. Others, on account of their great dimensions, are well suited to constructive works on a large scale.

Owing to their importance in both joinery and cabinet-making, the Leguminosæ certainly merit the attention of the planter. In order that he should reap the fullest benefit from any undertaking he should be acquainted with the merits of each species of wood.

The method of estimating the value of woods is often a vague one, and leaving on one side those woods which are already familiar, it is difficult to see how to classify the remainder.

Woods are usually classed as soft, semi-hard, or hard, but this method of classification is very difficult, and M. H. Courtet, in his treatise on the woods of the Ivory Coast, proposes to determine the density mathematically and to discard the vague term of hardness.

Very soft wood	...	...	...	Density less than 0·4
Soft ,,	...	...	...	,, 0·4 to 0·7
Hard ,,	...	...	...	,, 0·7 ,, 1·0
Very hard ,,	...	...	...	,, above 1

PAPILIONACEÆ.

Agati grandiflora (Tree).—An Indian tree of small size; the wood is soft, light, and suitable for planks.

Andira inermis (Tree).—A tree 10 to 15 metres high and 1 metre in diameter. The wood is hard and the colour externally blackish-red. In longitudinal section the wood somewhat resembles that of the palm tree, whence the name of *Bois palmiste* by which it is sometimes known.

There are a fair number of species of Andira in Brazil, and they furnish excellent wood for building purposes, cabinet making, &c.

Andira anthelmintica (bitter angelim).
Andira vermifuga (angelim).
Andira spectabilis (stone angelim).
Andira rosea (sweet angelim).
Andira stipulacea (coco angelim).
Andira racemosa is the Guiana angelim.

Æschynomene aspera (Shrub).—The Indian *sola*. A woody plant from 2 to 3 metres in height with a straight, gradually tapering stem which only branches towards the top.

The stem is formed by the agglomeration of white, spongy cells which form a compact mass without woody fibres. It is used for the light helmets, non-conductors of heat, which are commonly used in hot countries. This small tree bids fair to become the object of a fairly important cultivation, as it is also used in the manufacture of corks, fans, children's toys, mats, &c.

The wood is also used as an insulator for keeping drinks cool. The stems are used to make cases for carafes, bottles, glasses, and dish covers for ices, &c. Notwithstanding the heat of the surrounding atmosphere any iced preparation remains cool.

Æschynomene indica is a substitute for *sola*, and the same applies to *Cassia mimosoïdes*, *Mimosa pudica*, and *Sesbania paludosa*.

Baphia laurifolia (Tree).—There is a large traffic in this wood on the African coast between Cap des Palmes and Grand-Bassam. It is heavier than water, compact, finely grained, and takes a fine polish. When newly cut the inner wood is white, becoming red on exposure to the atmosphere. The outer surface is blackish, and when scraped it emits an odour resembling that of palisander or violet wood.

Baphia africana (Tree).—*Baphia laurifolia* gives a wood known as *camwood*. *B. africana* and *B. nitida* both give woods that go by the same name.

The *camwood* of Sierra Leone would be that of *Baphia nitida*. It is a very hard wood which takes a fine polish and is used in cabinet-making. The plant is a native of tropical Africa.

Butea frondosa (Tree).—A greyish-white wood, suitable for the charcoal used in the manufacture of gunpowder. In India it is used for wells, piles, &c., as it lasts better under water; occasionally found in interior building work.

Butea superba (Climbing Shrub).—A huge climbing plant. The wood is dark brown, very porous and fibrous.

Bocoa prouacensis (Tree).—A tree 10 metres high and one or more metres in diameter. The wood is very fine and well suited for cabinet-making, wood carving, musical instrument making, and turned work. Its sap-wood is almost as hard and compact as the wood itself. This latter is very hard and heavy and of an almost uniform brownish-grey colour. In a polished section one sees a stippling of grey on a brown background which is marked by a fine regular streak, stretching from the centre to the circumference, and only visible by means of a magnifying glass. In longitudinal section it shows an extremely fine grain and the colour is yellowish or brownish-grey besprinkled with small brown linear blotches. The boundary of the colour between the wood and the yellow sap-wood forms an almost regular circle.

Caragana brevispina (Shrub).—A spiny shrub with a light yellowish-brown wood. It is used for various purposes in India.

Caragana ambigua (Shrub). This species and *Caragana Gerardiana* are two Indian shrubs yielding a yellow wood with a hard red heart-wood.

Castanospermum australe (Tree).—A tree known as the "Moreton Bay Chestnut." The wood is hard and the colour white with a yellow tinge.

Centrolobium paraense (Tree).—A Brazilian building wood called *pau rainha*.

Centrolobium robustum (Tree).—The building wood *erriba*, of Brazil.

Centrolobium tomentosum (Tree).—An uncommon wood greatly valued for cabinet-making.

Colutea nepalensis (Shrub).—One of the few shrubs of the Himalayan valleys yielding wood: very common near Simla (India).

Cordyla africana (Tree).—The average height of this tree is 10 metres, with a diameter of 70 cm. The bark is thin and the wood finely-grained and compact. Although hard it is a good wood to work, and is not attacked by worms or ants. It is suitable for cabinet-making, joinery, carpentry, carriage building, ship construction, ships' timbers, mortars and pestles, &c. According to M. Constancia, the weight of the cubic metre is 1·090 kilos. In the Sudan this tree grows in all kinds of soils.

Coumarouna odorata (Tree).—A large tree very common in Guiana. It is called guaiacum wood, and has the hardness of that species. It is pinkish yellow in colour and formed of very fine fibres, and has, in longitudinal section, the appearance of partridge wood with the colours toned down and merged into each other. It is chiefly used in making

shafts and mill wheels, and might be employed for making attractive pieces of furniture were it not often pierced by long galleries bored by an insect.

Its density is 1·153, and its breaking strain 385 kilos (Lanessan).

Crotalaria barbata (Shrub).—This large shrub has a yellowish-brown coloured wood which is used in India for various purposes. The wood of *Crotalaria fulva* is soft and yellow.

Cyclolobium (Tree).—A genus related to the *Dalbergia*. The wood is hard, coloured, and imperishable.

Dalbergia melanoxylon (Tree). The heart-wood of this tree is almost black, hard, finely grained, and compact, and is used in the manufacture of furniture. Owing to its capacity for both taking and retaining a polish it might well be used for veneering. It is a tree which never reaches great dimensions. It is a native of East Africa, and is known as *Ebène du Sénégal* (Senegal ebony).

It is from species of *Dalbergia* that *Palisander* is derived, the fine violet coloured wood, very hard and close grained, which is so much used in cabinet-making. The colour varies from nut brown to dark purple or blackish. It is very heavy and darkens on exposure to the atmosphere, turning a violet-brown colour. Particularly fine pieces of furniture are made with this wood. According to Guibourt, the English violet-wood or king-wood, which comes from Brazil, Cayenne, Madagascar, and China, is not derived from trees of the genus *Dalbergia,* but from closely related species.

Dalbergia latifolia (Tree). A tree from Southern India, which may reach great dimensions. The wood is extremely hard and close-grained. The sap-wood is yellow and small in size; the heart-wood is dark purple with black longitudinal rays. It is a good wood for joinery, and is known in England as *rosewood* and in India as *Bombay black wood*. It is used for making furniture, cart wheels, and agricultural implements.

Dalbergia laccifera (Tree). This species of *Dalbergia* is from 20 to 25 metres high, and has a diameter of 40 to 60 cm. The wood is brownish-grey, and is particularly good for veneering.

Dalbergia congesta (Climbing Shrub).- An Indian plant with a soft, white, porous wood.

Dalbergia ferruginea (Tree).- This species and *Dalbergia heterophylla* are very useful woods, and are fairly largely employed in India.

Dalbergia cultrata (Tree).- A tree of medium height. The wood is black with dark purple streaks and very hard; the sap-wood is pale brown. This wood is used in India for making ploughs, bows, lance-shafts, &c. It is also used for carving.

Dalbergia bolnensis (Tree). In Madagascar the *Sakalaves* call this tree *manipika*. The trunk may be from 10 to 25 metres high and the diameter may be sometimes as much as 30 to 40 cm. The wood yields

one of the Madagascan palisanders. Bark yellowish, the flowers white, with a strong and penetrating odour. The trees grow to a certain extent everywhere except in wet soils.

Dalbergia Baroni and *D. trichocarpa* also occur in Madagascar, and might be exploited.

Dalbergia ovata (Tree).—The wood of this tree is grey or yellowish-brown in colour, close grained and fairly hard; it is used in India.

Dalbergia rimosa (Tree).—A small Indian tree with soft, white wood and a small amount of black heart-wood.

Dalbergia Sissoo (Tree).—This tree is a native of the mountainous parts of India; the timber is excellent, of fine, close grain. The sap-wood is very thin, and the heart-wood brown. It is extremely durable, never cracks, and is used in making boats, carts, ploughshares, &c. This is one of the best Indian woods.

Dalbergia volubilis (Shrub).—A large Indian climbing plant with hard pale-brown wood.

Dalbergia cochinchinensis (Tree).—This species is a tree some 30 metres high and from 60 to 90 cm. in diameter. The heart-wood is red (the colour growing darker with age), finely grained, compact, hard, and exceeds the sap-wood in size.

According to Lanessan, it is one of the most beautiful woods known, and suitable for all kinds of building work, joinery, and cabinet-making. When shielded from stress of weather it may live from fifty to sixty years. It is used as the base for the Tonkin mosaics. This tree is now rare in Cochin China.

Dalbergia hircina (Tree).—A tree of medium height with no duramen, the wood being fairly hard.

Dalbergia Perrieri (Tree).—This tree and the variety *Dalbergia boinensis* occur in the region of Boina, in Madagascar. It measures 10 to 20 metres in height, and the diameter sometimes reaches 60 cm.; the bark is greyish. This species thrives best in dry forests, in siliceous soils.

Dalbergia purpurea (Tree).—A large tree with compact white wood turning pale yellow on exposure to the air.

Dalbergia nigra (Tree).—This variety produces an excellent building wood which is also used for cabinet-making. Its common name in Brazil is *black jacaranda*. The Brazilian palisander wood also comes from one of these varieties.

Dalbergia paniculata (Tree).—A large tree with a white wood turning to pale yellow. It is of small worth.

Dalbergia Kurzii (Tree).—The wood of this tree is hard and yellowish-white in colour. The heart-wood is black and resembles ebony.

Dalbergia stipulata (Shrub).—A large climbing or erect shrub. The wood is greyish-brown, with a hard purple-brown duramen.

Dalbergia Oliveri (Tree).—A large tree yielding very handsome wood. It is hard, close-grained, with white sap-wood and a dark reddish-brown heart. It is used to a considerable extent in India.

Dalbergia spinosa (Shrub).—According to Kurz, this wood is smooth, silver-white in colour, and close-grained. Occasionally the colour is brownish-white.

Dalhousiea bracteata (Shrub).—A climbing shrub occurring in India, with a soft yellowish-white wood.

Derris robusta (Tree).—According to Roxburgh, this is an exceedingly quick-growing tree. The hard brown wood is used in India.

Desmodium.—The genus *Desmodium* includes shrubs the wood of which is used in India. The chief is *D. tiliæfolium;* the wood of this variety is yellowish-brown with a dark centre; it makes a good fuel. The varieties *D. umbellatum*, *D. cephalotes*, *D. pulchellum*, *D. confertum* yield hard woods varying in colour from white to yellowish-white and dark grey.

Diplotropis guianensis (Tree).—In this tree the sap-wood is as hard as the duramen; they both show very strong interlacing fibres. The wood is used for making wheel hubs, pump casings, recoil checks for guns, and railway sleepers.

The density is 0·991; breaking strain, 283 kilos.

Erythrina Corallodendron (Shrub).—This species is chiefly used to mark the boundaries of estates. It is a spiny shrub with a soft, spongy wood bearing terrible spines and forming impenetrable hedges. It is a native of the West Indies, and in the West Indies the wood, which is white, is used in cabinet-making and is termed in French *bois d'immortelle*.

Erythrina indica (Tree).—The carob-tree of India. It is cultivated both in that country and in Burma. At certain periods of the year it loses all its leaves and only retains the scarlet flowers. This tree is 10 metres in height and 1 metre in circumference; the wood is white and soft and is used by the *mouchis* to make statuettes and toys; it is also used for making boxes, light objects, &c.

Erythrina suberosa (Tree).—A medium-sized tree with soft, light and fairly durable wood. It is used for various purposes, such as making sieve frames, flooring, &c.

Ethyrina arborescens (Tree).—This Indian wood is more compact than that of *suberosa*, and it is used for the same purposes.

Erythrina stricta (Tree).—A tree which is nearly always found in the vicinity of watercourses in Cochin China; the wood is used for the same objects as that of the preceding species, but is not regarded as being of the same value.

Ferreirea spectabilis (Tree).—A resinous building wood used in Brazil.

Herminiera elaphroxylon (Tree).—The wood of this tree is porous, and much lighter than cork. Fishermen use it for making floats for their nets.

Indigofera (Shrub).—Use is made of the wood of a few of the indigo plants in India. The wood of the shrub is generally hard and white in colour with a black heart-wood. The species are *Indigofera heterantha*, *I. hebepetala*, *I. pulchella*. *I. stachyodes* yields a hard wood of marbled yellowish-brown colour.

Lespedeza eriocarpa (Shrub).—An erect shrub with a hard wood in which the sap-wood is yellow and the heart-wood red.

Lonchocarpus oxycarpus (Tree).—A species which is very common in Martinique. It yields a good wood for building, carriage work and marquetry. There is also an undetermined species of *Lonchocarpus* which is called *savonnette blanche*.

Lonchocarpus sericeus (Tree).—In Senegal this tree is regarded as one of the most valuable species. The wood is finely grained, hard and compact, and takes a fine polish. It resembles satin-wood and is used for turned work and cabinet-making. According to Lanessan, it is found throughout Cazamance and Gaboon.

Machærium Allemani (Tree).—This tree yields one of the varieties of Brazilian palisander wood. The wood is pale red with a few darker veins; it is compact, hard, and resembles rose-wood.

Machærium Schomburgkii (Tree).—This variety is known in Guiana as *Bois de lettres marbré*. The wood is hard, heavy, and particularly suitable for cabinet-making. It also goes by the name of Tiger-wood.

In Brazil several species of *Machærium* yield woods suitable for cabinet-making, building purposes, &c.; *M. leucopterum* (spiny jacaranda); *M. firmum* (purple jacaranda); *M. auriculatum* (pau de moco); *M. violaceum* (violet jacaranda).

Myroxylon peruiferum (Tree).—The wood of this tree is used for building purposes in Brazil, and is also utilized in many other ways. Its popular name is the *Oléo rouge*.

Milletia (Tree). There are some species of *Milletia* in India which produce woods used for commercial purposes in that country. *Milletia pulchra* is a tree with a hard, light-brown close-grained wood. The wood of another species, *M. pendula*, is hard, nicely figured, and purplish-black in colour.

The remainder are climbing plants: *e.g.*, *M. racemosa*, a light-brown wood with a red centre, and *M. auriculata*, yielding a white wood.

Mundulea suberosa (Tree). A small tree with a hard, close-grained wood. Colour yellow, the heart-wood darker. Used in India and has a considerable resemblance to satin-wood.

Myroxylon peruiferum (Tree).—The wood is used in Brazil for building and other purposes.

Nissolia arborea (Tree).—A thorny tree known in Guadeloupe as *Savonette rouge.* Yields a building wood with a density of 0·800.

Ougeinia dalbergioides (Tree).—A tree of medium size with a hard, close-grained wood; the sap-wood is thin and grey in colour; the heart-wood has a watered pattern, and is light brown or sometimes red-brown in colour. It is used in India for cabinet-making and various other purposes.

Peraltea erythrinæfolia (Tree).—The Brazilian *Rose angelim.* The wood is excellent for building purposes and is also used in cabinet-making, &c.

Pongamia glabra (Tree).—This is the species known as *Indian beech.* It is very common in the South of India. It is of pleasing aspect and well adapted for forming avenues. When in flower it presents a particularly agreeable appearance. It is now common in a number of tropical countries. The seeds contain 27 per cent. of oil with a poisonous smell and a bitter flavour. In the presence of sulphuric acid its colour changes to vermilion. The poor classes use this oil for lighting purposes.

The wood is fairly hard, white, beautifully grained and suitable for cabinet-making, &c. It is also a good fuel.

Pongamia uliginosa (Tree).—Like that of the preceding species, the wood of *Pongamia uliginosa* is good for joinery and cabinet-making.

Pterocarpus angolensis (Tree).—This species produces the wood known as Bar-wood and the red sandal-wood of Africa. It is common in Africa and the Gaboon Coast.

The colour of the inner wood is blood-red, that of the outer somewhat blackish; its structure is coarse and fibrous. It contains a red colouring matter, *santaline*, and a white crystalline compound, *santol.* The wood is very hard, takes a polish and is used in veneering, cabinet-making and turning. Particularly fine pieces of large furniture are also made from it. Gaboon is capable of supplying large quantities. It is a wood which fetches high prices in the European markets.

Pterocarpus erinaceus (Tree).—This tree may reach 12 to 15 metres in height. The wood is red in colour veined with white, fine-grained, very hard, compact and suitable for shipbuilding, carpentry, and cabinet-making. This *Pterocarpus* is a native of Senegal, and is one of the species yielding the red sandal-wood, which is exported in logs in large quantities from the French Congo.

Pterocarpus Adansonii (Tree).—The wood has the same qualities as the foregoing, and is known as *Sang-vene.* It is a native of Senegal.

Pterocarpus indicus (Tree).—This tree is found in a number of colonies, and is a native of India. The wood is white, but turns a fine red after a certain amount of exposure to the atmosphere; one of the sandal-woods.

It has a coarse fibrous structure, and the fibres are arranged in concentric layers running in opposite directions, in such a way that when split along its diameter it separates into two pieces one toothed into the other, and when planed the surface is alternately smooth and rough. This wood is very hard, heavy and strong, and is used for building work and coach-building.

Its density is 0·963; its breaking strain 15 kilos.

Pterocarpus Marsupium (Tree).—Very common in the forests about the base of the Nilgherry group in India. It reproduces very easily from seeds. The wood is reddish, very fine grained, hard and compact; it is strong, heavy and resinous and can be given a fine polish when being worked. It can be used for turned work, cabinet-making, joinery, railway sleepers, &c. This tree is a native of East India (Coromandel).

Pterocarpus suberosus (Tree).—Also known as *Montouchia suberosa*, the common name being *Bois chatousieux;* it is a tree from 14 to 16 metres high.

Guibourt says the wood is porous and light; the sap-wood is white, the heart-wood is of irregular shape and when cut transversely shows figuring roughly resembling a geographical map. Such a section shows all kinds of colours from bright red to violet and from auburn to dark chestnut. Although not held in much esteem it none the less yields pieces in which the irregular blend of red and dark chestnut gives a particularly fine effect.

Its density is 0·875 and its breaking strain 255 kilos. This tree is common on the marshy banks of the rivers of Guiana where it is indigenous.

Pterocarpus santalinus (Tree).—The real sandal-wood is not derived from this species. The wood of this tree, which inhabits the Coromandel Coast (India) is known as *Bois de coliatour*. It is of a dark red colour, very hard, and capable of taking a fine polish. In India it is used for making beams for building purposes. It is also used for carving, making picture frames, boxes, and other similar objects.

Pterocarpus macrocarpus (Tree).—An Indian tree giving a fine, hard, close-grained timber. The colour is dark brick-red.

Pterocarpus dalbergioides (Tree).—A very large tree with a fairly hard wood. The sap-wood is thin and grey in colour, while the heart is a brilliant red striped with brown and black. It is a building wood, used for a number of other purposes. The commercial name is *Padauk*.

Pericopsis Mooniana (Tree).—A large Indian tree with a pale orange-brown coloured wood. It is very hard and largely used for joinery, &c.

Priotropis cytisoides (Shrub).—An Indian shrub of erect growth. The wood is white.

Robinia pseudo-acacia (Tree).—The wood of this tree is used in India. It is hard; the sap-wood is white and the heart-wood yellowish or reddish-brown.

Sabinea rubiginosa (Tree).—The wood is very durable underground and is good for joinery and carpentry. The tree is commonly known in Gaudeloupe as the *caconier*. Density, 0·735.

Sebania ægyptiaca (Shrub).—The wood of this species and of *Sesbania grandiflora* is soft and perishable. It is used in making toys, charcoal for gunpowder, &c.

Sophora glauca (Shrub).—The wood of this species is white. That of *Sophora mollis* is hard, with grey sap-wood and brown heart-wood. They are both used in India.

Sophora japonica (Shrub).—The wood is compact, hard and uniform, and is used in cabinet-making.

Sophora tetraptera (Tree).—A large tree inhabiting Chili and New Zealand, the wood of which is extremely hard. It is chiefly used for making cog-wheels, waggon axles, &c.

Spatolobus Roxburghii (Shrub).—A climbing shrub sometimes as much as 1 metre in circumference. The wood is dark brown, very soft and fibrous.

Swartzia Langsdorffii (Tree).—The *jacaranda banana* of Brazil. Suitable for building, cabinet-making, &c.

Swartzia tomentosa (Tree).—In Cayenne this wood is known as *pagaie blanc* (white paddle), and is used for making oars.

Tounatea panacoco (Tree).—The wood of this tree is known as *Panacoco wood* or *partridge-wood*. It is one of the biggest and tallest trees in Guiana. The trunk is supported by seven or eight wings united in the centre along the whole of their height, which is from 2 metres 30 cm. to 2 metres 60 cm. These wings, which are known as *arcabas*, are from 12 cm. to 16 cm. thick and are gradually prolonged as they approach the soil, forming cavities from 2 metres 20 cm. to 2 metres 60 cm. wide by the same depth. The wings are used to make paddles. (Lanessan).

The trunk-wood is reddish, very hard and very compact; the sap-wood is white. A polished section shows a white stippling, which is not so close as in the *boco*, and a number of concentric white lines. The wood is called *partridge-wood* because when sawn along its length it shows white hatchings on a reddish ground roughly resembling the wing of a partridge.

Density 1·208; breaking strain 402 kilos.

This wood is fairly common in Guiana, and is used in high-class cabinet-making. It is also used for the grooved discs of pulleys.

Tipuana (Tree). A genus closely related to *Dalbergia*. In tropical America the wood is utilized in various forms. It is hard, coloured, and imperishable.

Tephrosia (Shrub).—According to Gamble, the wood of some of these shrubs is used for various purposes, *e.g.*, the species *candida* and *purpurea*.

Zollernia mocitahiba (Tree).—In Brazil this variety yields a timber known as *mocitahiba* which might be used for cabinet-making.

CAESALPINIEÆ.

Afzelia africana (Tree).—The wood of this tree is difficult to work. It is hard, close-grained, and of a light violet colour, or rose mahogany with darker streaks. It is suitable for cabinet-making, turning and visible joinery work. The branches give good curves for ship-building. This tree is common on the banks of the Cazamance in Senegal and the Ivory Coast. Its density is 0·906 (Courtet).

Afzelia bijuga (Tree).—Common in Madagascar. The wood is very difficult to work; only the heart-wood is employed. This is hard, close-grained, and reddish-brown in colour, and is used to make oil presses, pestles, &c. It is exported from Madagascar, where it is known as *false guaiacum*. It is also used for constructional purposes.

Afzelia bracteata (Tree). Occurs on the West Coast of Africa. The wood has similar qualities to that of *A. africana*.

Afzelia madagascariensis (Tree).—This tree grows in Nossi-Bé and is known to the Creoles as *guaiacum* and to the Madagascans as *fany guaiacum*. The wood is used for carpentry.

Afzelia palembanica (Tree). A native of the Malay Archipelago, known as *mirabow*, the wood of which is used for building, cabinet-making, &c.

Aloëxylun Agallochum (Tree).—Produces the famous aloes-wood, renowned for its fragrant perfume and its medicinal properties.

Apuleia præcox (Tree).—A Brazilian building wood, called *grapéa-punha*.

Apuleia ferrea (Tree).—In Brazil this wood, known as *pau ferro*, is in great demand for building purposes.

Bauhinia acuminata (Tree).—A tree found in Sierra Leone, Gaboon and Senegal. It may be from 40 to 60 ft. high. The timber, which is of fairly large size, is good for joinery and carpentry. In India it is used for making chests. It yields a kind of ebony.

Bauhinia Adansoniana (Tree).—The wood is used for cabinet making, joinery, and coach-building. It is hard and durable.

Bauhinia parviflora (Tree).—The wood is fine and closely grained, and, though somewhat hard and heavy, is easy to work.

Bauhinia purpurea (Tree).—A large tree 6 to 7 metres high. The wood is fine and closely grained, rosy-white in colour, turning brown on exposure to the atmosphere. It is hard, durable, and is used for carpentry and joinery when large enough; otherwise it is used for agricultural implements. A native of the East Indies.

Bauhinia reticulata (Shrub).—This plant is frequently met with in Senegal. The wood, though of rather small dimensions, may be used for cabinet-making, joinery, and carriage building. It is hard, durable, and easy to work. A native of Senegal.

Bauhinia rufescens (Shrub). The wood is used for joinery.

Bauhinia variegata (Tree).—The greyish-brown wood is used similarly to that of the preceding species.

Berlinia acuminata (Tree).—A tree reaching a height of 15 to 20 metres, usually very slender. Yields a white building timber, used by the natives for making canoes, drums, &c., joinery, cabinet-making, carving, turning (Autran).

Berlinia sp. (Tree).—A large straight tree, common in Senegal and the Soudan, which grows to a small extent in all soils. The height may be as much as 15 metres, with a diameter of 90 cm. Its wood is easy to work, but is subject to attacks by grubs and ants; it is good for cabinet-making, carpentry, carriage building, ship-building (planks and frame timbers). Weight of 1 cubic metre is 726 kilos (Constancia).

Bowdichia virgilioides (Tree).—A Brazilian building wood of excellent quality known as *sucupira parda*.

Bowdichia major (Tree).—A very hard wood, used in Brazil for making press-axles, mill-wheels, and other articles subject to considerable and continuous strain.

Cassia fistula (Tree).—This is a light wood of small size and a coarse grain; the colour is reddish or brick-red and darker towards the centre. It blackens in the air and is not durable. It is easy to work, and is used for the handles of tools, &c. It is an excellent firewood.

Cassia fastigiata (Tree).—This species of Cassia gives a durable wood with a fine, close grain.

Cassia marginata (Shrub).—Gives a very hard wood of pale-brown colour. It is solid and durable. It is used in India in the manufacture of wheel-axles, tool-handles, &c.

Cassia siamea (Tree).—A tree of average size occurring in India, where the wood is used to make tool-handles, bâtons, mallets, &c.

It is a hard timber, the sap-wood is white, and the heart-wood dark brown.

Cassia nodosa (Tree).—The wood of this tree is fairly hard. The sap-wood is light-brown in colour, and the heart-wood red. It is common in India.

Cassia timorensis (Tree).—A small tree with a dark-brown, almost black, wood, which is used in India for various purposes.

Cassia marcanahyba (Tree).—Yields in Brazil the building wood known as *canella marcanahyba*.

Cassia Sieberiana (Tree). Grows in all soils from the Soudan to Senegal. The tree reaches a height of about 5 metres; it is somewhat crooked, fairly hard to work, and is free from the attacks of grubs and ants. The wood is good for cabinet-making, joinery, carpentry, turning, coach-building, tool-handles, pestles, mortars, &c. The weight of 1 cubic metre is 504 kilos (Constancia).

Cæsalpinia crista (Tree).—This wood, known as *Brazil-wood*, is of small dimensions and is good for marquetry.

Cæsalpinia echinata (Tree). -A building wood, the *pau Brésil*.

Cæsalpinia ferrea (Tree).- -A Brazilian building wood known as *juca* or *pau ferro commun*.

Cæsalpinia ferruginea (Tree).-- A fine-grained wood of high density. It is easy to work and may be used for cabinet-making.

Cæsalpinia Sappan (Climbing Shrub).—The wood of this shrub is chiefly utilized for dyeing purposes, but is also used for making bolts. The sap-wood is white and the heart-wood orange-yellow; it takes a fine polish.

Ceratonia Siliqua (Tree).- The wood of the carob tree becomes very hard with age. The fine dark-red veining makes it suitable for cabinet-making and marquetry.

Cercis Siliquastrum (Tree).—This species is known as the Judas tree. The wood may be used for cabinet-making; it is nicely veined with brown and yellow, and the fineness of the grain allows of a good polish.

Copaifera bracteata (Tree).—A common tree with several popular names, such as *Violet-wood*, *Amaranth*, *Simeridis*, &c. It is of high growth. The wood is compact, heavy, very fine in texture, and a section cut transversely to the axis shows a very fine close stippling arranged in wavy lines.

The wood when newly cut is dark-grey in colour, rapidly turning to a uniform violet when exposed to the air. When the wood is polished the colour becomes reddish-brown. This wood is often confused with *Violet-wood*, which is rarer and more costly, and which is further distinguished by its distinct veining (Lanessan).

Copaifera guianensis (Tree).—A Brazilian building wood, which is commonly known as *copahiba.*

Copaifera pubiflora (Tree).—This variety is also said to give a kind of amaranth-wood. This wood, similar to that of *C. bracteata,* is solid, durable and elastic to a degree, and is consequently used for all sorts of building purposes, cabinet-making, and the manufacture of platforms for gun pieces.

Copaifera officinalis (Tree).—A rare native of New Zealand. The wood is used for marquetry.

Crudia zeylanica (Tree).—A tree 20 metres high by 40 to 60 cm. in diameter. The wood is white and the heart-wood brown. Unless used when very dry it is not very durable. It is useful for planks and timbers.

Cynometra polyandra (Tree).—A large evergreen tree with pale-red wood of close grain. Used for buildings.

Cynometra ramiflora (Tree).—A tree 10 to 12 metres high, the wood of which is red, hard, and close grained. It is used in house-building and for making carts and wagon-shafts. It is a good firewood.

Detarium guineense (Tree).—A wood from Tropical Africa, called *Dattock*, used for building and cabinet-making.

Detarium microcarpum (Tree).—Very common in Senegal and the Soudan. This tree grows to some 7 metres high, and does best in dry soils. The trunk is straight, with a hard, fine-grained wood; it is easy to work, and is used in cabinet-making, joinery, carpentry, ship-building, and for making piles. Weight of 1 cubic metre is 688 kilos (Constancia).

Detarium senegalense (Tree).—This tree, which is very common in Senegambia, yields a wood suitable for joinery, veneering, carpentry, and even for ship-building.

Dialium coromandelinum (Tree).—A large tree with a hard grey wood, which is used in India.

Dialium indum (Tree).—This is one of the best timber trees in Cochin China; it is rare in the plain and fairly common in the mountains. The tree is thornless, and from 15 to 20 metres high by 60 to 80 cm. in diameter. The wood is red or brown and of showy appearance, finely and closely grained, heavy, and very durable.

Dialium nitidum (Tree).—Lanessan describes this species as follows: "The trunk is twisted and warped. The wood is hard, does not decay in salt water, and is therefore suitable for ship-building. It is equally suitable for fine cabinet work and turned work. The tree is thornless, and from 5 to 6 metres in height by 50 cm. in diameter."

Dialium ovoideum (Tree).—A large tree with a very hard close-grained wood, dark reddish-purple in colour. In India it is regarded as a first-class wood for joinery.

Dicorynia paraensis (Tree).—A large tree which is very common on the plateaux and slopes in the interior of Guiana. The common name is *Angelica-wood.* The wood is reddish in colour, fairly durable, homogeneous and pliant; the colour of the heart-wood is more distinct and darkens with age. It yields timbers 15 to 20 metres long by 30 to 50 cm. scantling. It is in large demand for ship-building, as it is impervious to damp and is not attacked by insects. It is also used for making handrails, railway sleepers, &c. Three varieties are known: black, red, and white. Density, 0·746; breaking strain, 215 kilos (Lanessan).

Didelotia Duparquetiana (Tree).—A tree 10 to 12 metres high. It yields an excellent rose-coloured wood, which is easy to work (Autran).

Dimorphandra excelsa (Tree).—The height of this tree may be as much as 40 metres. The wood is known as *mora-wood.* It is hard, with interlacing fibres, and is suitable both for building purposes and marquetry. In great demand.

Eperua falcata (Tree). This tree is very common in Guiana in the forests and on the banks of streams and rivers. The trunk is straight up to a height of 18 to 20 metres, when it divides into two or three large branches, which again subdivide. It may be up to 60 cm. in diameter, and its reddish wood is in great demand for building purposes, work under water or underground, especially where the soil is damp. In such cases its life is considerably longer than that of many other timbers. It is also used for match-boardings, which last for fifteen to twenty years.

Density 0·030; breaking strain 224 kilos (Lanessan). This tree is commonly known as the *Oily Woapa,* as it exudes a large amount of oil, one tree giving as much as 3 kilos.

Eperua grandiflora (Tree).—A hard wood used by the Indians for making musical instruments.

Erythrophleum ivorense (Tree).—A tree from 30 to 35 metres high, the diameter of the trunk being 60 to 80 cm. The wood is brown-red in colour and is used for coach-building and visible joinery. Density, 0·901 (Courtet).

Erythrophleum guineense (Tree).—A Senegalese tree, the wood of which is in great demand on account of its durability and freedom from decay. It is so hard as not to be charred in the fires which rapidly destroy the huts of the blacks. It is used in making chests and all kinds of domestic utensils. It is not attacked by ants (Lanessan).

Autran states that it is very common in Gaboon. The reddish-coloured wood is used for joinery, cabinet-making, marquetry, and turned work. The tree is 20 to 25 metres high.

Cleditschia sinensis (Tree).—The common name is *Févier.* The wood of this tree, which is planted in hedges, is coarse-grained and perishable. It is used for making mortars, troughs, &c., and is also turned into charcoal.

Hardwickia binata (Tree).—The wood is reddish-brown or nearly black in colour, very hard, and is greatly valued on account of its durability, even when buried in the ground.

Hardwickia pinnata (Tree).—A very large tree with a hard wood and a large amount of sap-wood. The heart-wood is of a dark-red colour. It is used in India for building purposes.

Hæmatoxylon campechianum (Tree).—This species is known by the familiar name of *Campeachy-wood*. The wood is hard, heavy, and compact, with a white sap-wood. The heart-wood is reddish-brown. The inner wood is very pale, but when polished and exposed to the air it acquires a bright-red tone. When exposed to damp in the rough state the colour turns black. It is largely used for cabinet-making.

Density, 1·003; elasticity, 1·3; breaking strain, 1·7 (Lanessan).

Hymenæa Courbaril (Tree).—The trunk of this tree may attain a height of 24 metres and a diameter of 2 to 3 metres. The species is very common in Guiana, where it is known as *Courbaril*. The name given to it in Brazil, where it makes an excellent building wood, is *Jatoba*.

This wood is easy to work and does not warp. As it grows older it acquires a mahogany tone and is covered with speckles, which have the appearance of being engraved. This tree is capable of yielding fine curves for ship-building: it is used for manufacturing furniture and all kinds of durable utensils. The Indians use the bark for making canoes.

The density is 0·904; breaking strain, 333 kilos.

The *Courbaril-wood* of commerce, which is used to make valuable pieces of furniture, is derived from *Astronium fraxinifolium*, belonging to the family of the *Anacardiaceæ*. This wood is red in colour, very hard and heavy, and a longitudinal section shows little furrows directed alternately in two different directions, rather resembling the strokes of an engraving needle.

Humboldtia (Tree).—The two species *Humboldtia vahliana* and *H. decurrens* yield a fairly hard, brown wood, which is used in India for various purposes.

Melanoxylon Brauna (Tree).—This species yields a building wood known in Brazil as *Brauna*.

Moldenhavera floribunda (Tree).—An excellent Brazilian building wood. Common name *Guarachi*.

Pahudia cochinchinensis (Tree).—A tree from 20 to 25 metres high and 80 cm. in diameter. Yields a fine, fairly heavy, red wood with a dense tissue, suitable for all kinds of building work and especially for coach-building. The primary branches are capable of providing curves.

Pahudia macrocarpa (Tree).—A tree 30 to 40 metres high and 1 metre in diameter. The wood is similar to that of the foregoing.

M. de Lanessan also adds that these two species are fairly rare except in Cambodia.

Parkinsonia africana (Tree).—The wood is used at the Cape for building purposes.

Peltophorum ferrugineum (Tree).– This species is fairly common in Indo-China and India, but trees of large diameter are rare. They may be from 20 to 30 metres in height and have a diameter of 60 to 90 cm. The reddish-brown wood is good for coach-building, cabinet-making, and all building purposes. The sap-wood is not used.

Peltogyne discolor (Tree).—The wood is used for building, and is known in Brazil as *Guarabu*.

Poinciana regia (Tree).—A large species with scarlet flowers. The wood is dry and brittle. It is a native of Madagascar. Density, 0·566; breaking strain, 15 kilos.

Poinciana elata (Tree).—The wood of this tree is yellowish-white in colour with an irregular red heart-wood. The tree is a native of India.

Saraca cambodiensis (Tree).—Tree 8 to 12 metres in height. Yields a reddish wood used for small jobs. Very common in Cambodia.

Schizolobium excelsum (Tree).—A Brazilian wood used for building and various other purposes. It is known as *bacurubu*.

Sindora siamensis (Tree).—A very large tree attaining a height of 25 to 30 metres and a diameter of 1 metre. The wood is brown or reddish-brown, compact, easy to work, and does not split when used dry. It is used for building and coach-building.

Storckiella Pancheri (Tree).—We merely note this tree, as the pinkish-white wood is difficult to work and is very subject to ravages by insects.

Tamarindus indica (Tree).—A fine tree, which thrives in all tropical countries. It may be from 12 to 15 metres in height and have a diameter of 1 or even 1½ metres. The wood is hard, dense, solid, close-grained, and yellowish-white in colour. It is good for coach-building and constructing curves for small craft. The trunk is used to make the Indian oil-presses. It is a good wood for cabinet-making, but is hard to work. Density, 0·964; breaking strain, 34 kilos.

Vouacapoua americana (Tree).—In Guiana this tree is called *Wacapou* or *Angelim à grappes*. It measures about 20 metres in height, by 65 to 70 cm. in diameter. Lanessan says that it is somewhat uncommon in the forests of the interior and that it possesses a very thin whitish sap-wood; the heart-wood, on the contrary, is very hard, imperishable, and invulnerable to insect attacks. The colour is dark-brown sprinkled with whitish blotches, the shape of which varies

according to the nature of the section. It makes an excellent wood for ship-building, carpentry, roof-boarding, cabinet-making, and railroad sleepers. It is very solid and durable and is very easy to work.

The species *Vouacapoua americana,* of Brazil, is an excellent building wood. Its common name is *acapu,* and it may be called Brazilian teak. Density, 0·900; breaking strain, 304 kilos.

MIMOSEÆ.

Acacia acuminata (Tree).—This tree, which is found in Western Australia, is from 12 to 15 metres high. The wood is used for cabinet-making and coach-building. Suitable for charcoal.

Acacia arabica (Tree).—A tree of medium size. The wood is hard, the sap-wood is whitish, and the heart-wood pinkish-white, changing to reddish-brown on exposure to the atmosphere. It is used for making agricultural instruments, plough-shares and handles, and also for spokes, axles, cart-wheels, &c.

This is not a very straight tree; the height may be from 8 to 10 metres; in dry, barren regions the wood becomes valuable.

Acacia Angico (Tree).—A Brazilian building-wood known as *angico.*

Acacia aneura (Tree).—This species occurs in Australia. It rarely exceeds 7 to 8 metres in height, but the exceptionally hard wood makes excellent tool-handles. It is the wood used by the aborigines for making their weapons—spears, boomerangs, &c.

Acacia Adansonii (Tree).—The common name for this tree in Senegal is *Gonakié.* It may reach a height of 10 to 12 metres. The wood has a very fine grain and is very hard and durable.

From Lanessan we learn that it is perfectly suited to ship-building, for elbowings, deck timbers, eking-pieces, and curves. It is difficult to work when dry. It is also used for piles and is extremely durable in this capacity, the water only hardening it and not causing decay. This acacia is very common on both banks of the Senegal.

Acacia altissima (Tree).—A good wood for cabinet-making. Senegal.

Acacia albicans (Tree).—A large tree, the wood of which is used for cabinet-making, as it is hard and the grain is fine and close.

Acacia albida (Tree).—This tree grows to a height of 9 metres and has a slightly rounded summit. The bark is fairly thick and the wood is hard and fairly easy to work. Grubs and ants are unable to harm it. The wood is good for joinery, cabinet-making, carpentry, coach-building, &c. Weight of 1 cubic metre is 555 kilos (Constancia).

This acacia is of erect growth and thrives in all soils. It is very common in Senegal and the Soudan.

Acacia astringens (Tree).—The height of this species may be as much as 9 metres and the diameter 60 cm. It grows in all kinds of soils.

It is an erect tree with an irregular summit, and the wood is very hard and close-grained. It is difficult to work when dry and is not attacked by pests.

The wood is suitable for cabinet-making, joinery, carpentry, coach-building, ship-building, turned work, wooden tools, pestles, mortars, boot-lasts, charcoal and piles for wharves. It hardens in water. Weight of 1 cubic metre is 950 kilos (Constancia).

Acacia capensis (Tree).—This acacia occurs in many parts of Africa and yields a wood which is good for joinery work.

Acacia Catechu (Tree).—A thorny tree of medium size. The wood is very hard, the sap-wood is yellowish-white in colour, and the heart-wood light or dark-red. It is easy to work, takes a nice polish, and is not attacked by white ants. It is also used in India for making railway sleepers.

Acacia decurrens (Tree).—A South Australian tree, the wood of which is used for building and cabinet-making; sap-wood and heart-wood reddish-brown.

Acacia dealbata (Tree).—This is an Australian acacia, which has spread to a certain extent to every portion of the globe. If less than 15 years old it is only suitable for firewood or for making charcoal. After that time it yields light planks, which are pale-red in colour and very durable.

Acacia eburnea (Shrub).—A solid and durable wood of darkish colour, which takes a fine polish. It is used in India for fuel.

Acacia Farnesiana (Tree).—This tree does not grow to any great size; the sap-wood is white, and the heart-wood irregularly red. The wood is used to make wheels, springs, handles, spokes, axles, &c.

Acacia ferruginea (Tree).—A large tree with a hard wood, the sap-wood being yellowish and the heart-wood olive-brown. Used for building, &c., in India.

Acacia gracilis (Tree).—This species is recorded as being very common in Senegal, with a wood suitable for cabinet-making.

Acacia heterophylla (Tree).—A native of the Sandwich Isles. It is known in Réunion as *Tamarinier des hauts*, and in Guadeloupe as *Wood tamarind* or *Mountain tamarind*. When sufficiently large it yields a speckled yellow wood which is used for building small water-craft and also for coach-building. It may be sawn into planks. Density, 0·405; breaking strain, 562 kilos.

Acacia Jurema (Tree).—A Brazilian building wood, called *Jurema*.

Acacia laurifolia (Tree).—A tree 8 to 10 metres high by 40 to 50 cm. in diameter. The wood is brown and scarcely usable on account of its lack of durability. It is said to give off a disagreeable smell when it is burnt.

Acacia latronum (Shrub).—A thorny Indian shrub with a very hard wood. The sap-wood is light-brown in colour, and the heart-wood small and red. It is only used for fuel.

Acacia lenticularis (Tree).—A thorny Indian tree the wood of which resembles that of *Acacia ferruginea* and serves the same purposes.

Acacia leucocephala (Shrub).—This shrub is only of small dimensions, the common name being *Macata bourse*. It is used for marquetry. A native of South America.

Acacia leucophlœa (Tree).—This tree is used in India for the wood portions of the native straw huts. It is a native of South America. The wood is hard, and the heart-wood is reddish-brown in colour. It is easy to work and takes a nice polish.

Acacia lophanta (Shrub).—Lanessan states that the wood is finely grained and of considerable density. It is easy to work and may be used for cabinet-making.

Acacia lutea (Tree).—This tree is very common in dry soils in Senegal. The wood is hard, close-grained, and good for coach-building and cabinet-making.

Acacia maleolens (Tree).—A Brazilian building timber, commonly known as *vinhatico*.

Acacia mexicana (Tree).—The wood is used for building purposes.

Acacia melanoxylon (Tree).—A South Australian tree, the wood of which is used for building and cabinet-making. The heart-wood is dark brown in colour with a watered pattern, light in weight, and not very durable.

Acacia microphylla (Tree).—According to Lanessan this species is very common in Senegal; the wood is bright yellow in colour with black veinings, and is very good for cabinet-making.

Acacia modesta (Tree).—A moderate-sized tree with a very hard wood, the heart-wood being dark-brown in colour with black stripes. It is stout and durable, and is used in India for making cart-wheels, &c.

Acacia myriadenia (Tree).—The species *myriadenia* is a tree 6 to 8 metres high by 40 to 50 cm. in diameter, but it may grow to a height of 20 metres. The sap-wood is white, thick, and very bad; the heart-wood is yellowish, solid, but pliable; the fibres are straight, and the pores are visible and elongate. The heart-wood stands water fairly well; it is suitable for coach-building.

Acacia nilotica (Tree).—A tree which is very common in the forests of Senegal. The wood is hard and very tough, and is rarely attacked by insects. It is used to make piles and fences for huts.

Acacia rubra (Tree).—A hard wood, finely and closely grained, which is very suitable for cabinet-making.

Acacia scleroxylon (Tree).—A thornless tree, measuring 12 to 15 metres in height by 50 cm. in diameter. According to notes by Lanessan the hardness of its wood is responsible for its being called *Tendre à caillou*, a name which it shares with several other species. The sap-wood is yellow; the heart-wood is hard, reddish, and imperishable, and is used to make poles, stakes, piles, &c. It is very common in the West Indies, where there is another acacia, of undetermined species, the wood of which is so hard that it has been nicknamed *Casse-haches* (Break-hatchet). *Acacia scleroxylon* has a density of 1·235; breaking strain, 2·658.

Acacia sp. There are several undetermined species of acacia in Senegal, called *Sourour*, *Moutout*, &c., which yield good wood for joinery. The wood of some is hard, finely and closely grained, and resembles box-wood.

Acacia spirorbis (Tree).—The common name of this species in New Caledonia is "*False Guaiacum*." The wood is hard enough to serve as a substitute for that of the *Guaiacum*, and is used for pulleys, wooden rollers, screws, &c. The sap-wood is yellow in colour, and in old trees is thin; the heart-wood is dark brown, very dense, and very close-grained. Density, 1·074; elasticity, 12·51; cohesion, 14·75.

Acacia speciosa (Tree).—In India this species is commonly known as Blackwood, as its timber has many characters in common with that of *Albizzia Lebbek*. The wood is used for making oil-presses. The heart-wood is brown or reddish-black in colour and fibrous in texture.

Acacia Sieberiana (Tree).—An erect tree common in Senegal and the Soudan. The wood is finely grained and somewhat hard. It is easy to work, but is attacked by grubs and ants. It is suitable for light furniture, packing-cases, pestles, mortars, &c. According to Constancia the weight of 1 cubic metre is 760 kilos.

Acacia Suma (Tree).—A small tree with a dark brown wood, very hard and heavy.

Acacia sundra (Tree).—The Indians consider the wood of this tree as being the most durable of all, and use it for the supports of their dwellings. It is reddish-brown in colour and very hard.

Acacia tenuifolia (Shrub). Known in Guadeloupe as *Bois d'amourette*. Suitable for cabinet-making and joinery.

Acacia Verek (Tree).—This small tree is of erect growth, attains a height of 4 metres, and is found in all dry soils. The wood is good for pestles; a cubic metre weighs 650 kilos (Constancia).

Acrocarpus fraxinifolius (Tree). One of the largest Indian trees, sometimes reaching a height of 40 metres. The timber is hard, the sap-wood is white in colour, and the heart-wood pale red. It is a good wood for joinery and building purposes.

Adenanthera falcata (Tree).—In the Moluccas the wood of this species is used to make shields.

Adenanthera pavonina (Tree).—A native Indian tree which has spread to nearly all tropical countries. The wood is hard, with grey sap-wood and red heart-wood, varnishes well, and is good for building and cabinet-making; the brown bands on a lighter background make a pretty design.

Albizzia amara (Tree).—A tree of medium height. The wood is very hard, the sap-wood is white, the heart-wood purple-brown with a distinctly watered pattern and alternating light and dark bands. It is close-grained and very durable. It is used in India for house and coach-building.

Albizzia bigemina (Tree).—A fine Indian forest-tree, the wood of which is valued for its dark-brown tint and its durability. This species and *A. subcoriacea* are both of large size and have similar qualities.

Albizzia dulcis (Tree).—The wood is used in India for manufacturing light objects.

Albizzia fastigiata (Tree).—A tree 20 to 25 metres in height with a trunk 30 to 50 cm. in diameter. The wood is yellowish-white in colour and is used for ordinary joinery work. The density is 0·625. Occurs on the Ivory Coast (Courtet).

Albizzia latisiliqua (Tree).—A large tropical American tree, the wood of which is veined to an exceptional extent. It is splendid for cabinet-making, and is said to be finer than mahogany.

Albizzia Lebbek (Tree).—The common name for this species is Blackwood. It is a shelter plant used in coffee and cacao plantations and may reach very big dimensions, 12 to 15 metres high by 1 metre in diameter. The wood, which is used for cabinet-making, joinery, coach-building, &c., is hard, full, solid, and well veined. The colour is white; that of the heart-wood is black. Density, 0·802; strength, 28 kilos (Lanessan).

Albizzia lucida (Tree).—A large tree with an extremely hard wood; the sap-wood is white, the heart-wood brown with dark stripes and light or dark concentric bands. It is used in India for buildings, carts, &c.

Albizzia mollis (Tree).—A medium-sized tree yielding a hard wood; the sap-wood is broad, the colour of the heart-wood is dark brown, and in old trees almost black. It is used for cabinet-making in India.

Albizzia odoratissima (Tree).—The wood is used in India for making oil-presses, axles, spokes and felloes of cart-wheels. It is easy to work and takes a polish, the colour is a fine brown with darker stripes. It is fairly durable provided it is protected from damp.

Albizzia procera (Tree).—A large tree of rapid growth. The wood is hard, with a broad, yellowish-white sap-wood. The heart-wood is brown and bright in appearance with alternating light and darker layers. This latter is durable and is used for making rice-pestles, wheels, bridges, posts, and agricultural implements. In India it is used for making packing chests for tea, and it also yields good charcoal.

Albizzia rhombifolia (Tree).- A tree 25 to 30 metres high with a trunk 60 cm. to 1 metre in diameter and no branches up to a height of 20 metres. The wood is reddish-yellow in colour with a density varying from 0·713 to 0·787. It is used in the construction of rolling-stock where a large amount of strain may be expected.

Albizzia stipulata (Tree).—The wood of this tree is used for making packing cases and other similar objects. It is soft and perishable.

Albizzia sp. (Tree).—An Indian *Albizzia* of undetermined species, the wood of which is used for timber work.

Albizzia Thompsonii (Tree).—A tree of average size. The wood, which is used in India, is hard, has a yellowish sap-wood and a dark brown heart-wood.

Albizzia tomentosa (Tree).—The wood of this species is hard, finely and closely grained, and good for turned work.

Calliandra Hildebrantii (Tree).—This tree is found in Nossi-Bé. The wood is of small size, but close-grained.

Dicrostachys cinerea (Tree).—A small tree with an extremely tough heart-wood, the colour of which is red with black stripes. It is used in India for firewood. Owing to its toughness and solidity it is also used for making walking sticks.

Enterolobium lutescens (Tree).—A Brazilian building wood, known as *Cabuhi vinhatico*.

Inga Burgoni (Tree).—The wood of this tree is used in Guiana, and is known as *Palétuvier de Montagne* (Mountain mangrove). It has no durability and is of small value. In Martinique it is used for chair-making and interior building-work.

Inga ferruginea (Tree).—In Martinique this species is known as *Pois doux gris*. It is very common and the wood is good for marquetry.

Inga martinicensis (Tree).—A thornless tree suitable for building work. The wood is white and rather soft. Density, 0·769; breaking strain, 1·078. It is very common in Martinique at an altitude of 300 metres.

Inga salutaris (Tree).—A rather rare wood suitable for marquetry.

Inga Saman (Tree).—The wood of this species, which is rare in India, is used for making chairs and other furniture.

Mimosa rubicaulis (Shrub).—A large thorny shrub with a hard wood, the sap-wood is yellowish in colour, the heart-wood red. The charcoal is used in the manufacture of gunpowder.

Parkia biglandulosa (Tree).—The wood of this fine species is extremely pretty. It is finely grained and takes a beautiful polish. M. Achart thinks that it might be used to great advantage in cabinet-making and turned work.

Parkia biglobosa (Tree).—A good quality wood suitable for joinery.

Parkia Roxburghii (Tree).—Yields a grey wood used in India.

Parkia streptocarpa (Tree).—Tree 25 metres high and 60 cm. in diameter. A white wood with a brown heart-wood; used for all kinds of building work.

Pentaclethra filamentosa (Tree).—The wood is very good for building and cabinet-making.

Pentaclethra macrophylla (Tree).—This tree is very common in Gaboon and often reaches a height of 20 to 30 metres. The wood is reddish, very hard, and good for cabinet-making, building, turning, coach-building, paving, &c. M. Autran states that this species never grows in forests, the trees are isolated and prefer dry soils.

Piptadenia africana (Tree).—A tree 12 to 15 metres high. The wood, which is used in the Congo, is white and tough. It is used in joinery, cabinet-making, turning, &c. Density 0·633.

Piptadenia oudhensis (Tree).—A tree of average size. The wood is reddish or yellowish in colour, close-grained, tough, and very durable. There is no heart-wood. It is useful in India.

Piptadenia rigida (Tree).—Yields a very solid timber used for ship-building.

Pithecolobium. There are a number of species of *Pithecolobium*. The wood of some is white, of others red. In some the wood is hard or semi-hard, in others rather softer. The various species are employed for various purposes, *e.g.*, cabinet-making, joinery, building, &c.

Among species with hard wood may be quoted *P. filicifolium*, *Schomburgii parvifolium*, *Unguis-cati*, *micradenium*. Several of these are known in Guiana as *Bois macaque* (*Ape-wood*).

Those with softer wood are: *P. trapeziforme*, *pedicellare*, *corymbosum*.

Pithecolobium bigeminum (Tree).—A large tree with a brown wood. In India it is made into planks, &c., but it is difficult to work.

Pithecolobium dulce (Tree).—A tree which varies in height according to its environment. The wood is white, with a tough, pale-red heart-wood. It makes a good fuel.

Pithecolobium gummiferum (Tree).—A Brazilian building wood known as *Red Angico;* it is also used for cabinet-making.

Prosopis glandulosa (Tree).—This wood is almost equal to mahogany in toughness and beauty, and is therefore excellent for cabinet-making.

Prosopis spicigera (Tree).—A tree of average size, yielding a very hard wood with broad whitish sap-wood and purple-brown heart-wood. An excellent fuel. Used in India.

Stryphnodendron Barbatimam (Tree).—This species is known in Brazil as *barbatimao,* and the wood is used for building, cabinet-making, &c.

Xylia dolabriformis (Tree).—A very lofty tree, which may be from 25 to 30 metres in height by 80 cm. to 1 metre in diameter. The wood is red, reddish-brown, or dark-brown in colour, finely and closely grained, very tough, heavy, fibrous, and very durable. The sap-wood is very small and is not used. This is one of the best species of timber known, and it is excellent for cabinet-making, joinery, and building construction.

The natives of Cochin China use it for planks, posts for bridges, props for houses (Lanessan). Gamble says that it has the drawback of being heavy and difficult to cut.

CHAPTER XIV.

MEDICINAL LEGUMINOSÆ.

Many of our colonial plants have acknowledged therapeutic properties, and are used with success in the treatment of numerous complaints.

It is interesting to know the *rôle* played by the Leguminosæ in this particularly useful class of plants, and we have therefore given an account of the views of doctors and writers of reputation, such as Daruty, Bocquillon-Limousin, Corre, Lanessan, &c.

We will restrict ourselves to a mention of their possible applications and of the active principles which they have been found to contain.

PAPILIONACEÆ.

Abrus precatorius (Climbing Shrub).– This plant has a wide distribution in the Tropics. The roots are sweet and cooling, and are used in the same way as European liquorice; it is an expectorant.

According to Bocquillon-Limousin the seed contains a diastase, *Jéquiritin* or *Abrin*, yellowish-brown in colour, and soluble in water. The chief use of the seed is after maceration, for treating granular conjunctivitis.

Agati grandiflora (Tree).--The bark has febrifugal and the leaves diuretic properties. It is an external remedy for bruises (Daruty). The juice of the flowers is a popular remedy for coryza, the leaves are bitter, astringent, and laxative; the root, when converted into a paste mixed with water, is used for rheumatism; the juice of the root mixed with honey forms an expectorant.

Anagyris fœtida (Plant).—This plant contains an alkaloid, *Anagyrin* ($C_{14}H_{18}Az_2O_2$). The alkaloid is extracted from the seeds and prepared in the form of anagyrin chlorhydrate. It is a poison, producing vomiting and a slackening of the respiration.

An infusion of the leaves acts as a purgative; the pounded leaves are used externally for treating tumours. The leaves are emetic and emmenagogue; an infusion of the stem and root is used as a purgative and as an anthelminthic (Bocquillon).

Aspalathus arborea (Tree).—The leaves are demulcent (Lanessan).

Baptisia tinctoria (Herb).—The plant contains three principles: *baptisin*, a bitter glucoside; *baptin*, a purgative glucoside; *baptitoxin*, an extremely poisonous alkaloid. In large doses it is emeto-cathartic; in moderate doses it is laxative (Bocquillon). This is the leguminous plant known in Mexico and the United States as *Wild Indigo*.

Butea frondosa (Tree). In India the seeds are used as a purgative (Lanessan). They yield an oil used in frictions for the treatment of rheumatism. The crushed leaves are employed for leprosy and diseases of the skin. The juice of the root is used internally for blennorrhagia and externally for ulcers (Bocquillon).

Cajanus indicus (Shrub). Bechic, strongly diuretic, astringent, detergent. Gravel, hæmorrhage (Daruty).

According to observations by my colleague, M. Desruisseaux, the fresh seeds have a marked action on periodical incontinency of urine in man. When fresh seeds are eaten daily the involuntary emission of urine during the night ceases, but recommences when the seeds are no longer taken. The action of the active principles, which, apparently, only exist in the fresh seeds, seems to be transitory. Certain remedies for incontinency of urine contain a substance called *Cytisin*: this is the alkaloid of a leguminous plant and acts favourably on the bladder.

The dried leaves, when powdered and taken in doses of three spoonfuls a day, often aid in passing small stones from the bladder.

Cicer arietinum (Shrub). The leaves and stems of this plant yield, when pressed, an acid juice. This latter is used for dyspepsia and constipation (Lanessan).

Clitoria terneata (Liane). Laxative and diuretic, also used for fever and dropsy (Daruty). The root has diuretic and emetic properties; it is also used in powder form for croup. The variety with white flowers is the most sought after.

The root has purgative and diuretic properties. In the form of an alcoholic extract it constitutes an extremely violent purgative. In the form of an infusion it acts as an emollient in irritation of the bladder and urethra. The seeds have a purgative action which is both prompt and sure (Bocquillon).

Crotalaria verrucosa (Shrub). The juice of the leaves diminishes salivation. Scabies; impetigo (Daruty).

Crotalaria juncea (Shrub). In India the seeds are used as a blood purificant in certain diseases.

Dalbergia arborea (Tree). The fresh roots are used for cleansing ulcers.

Derris elliptica (Shrub). In Borneo and Java the Malayans use the roots for poisoning fish.

Taken internally in small doses, *Derris* has considerable narcotic properties. Gresshoff has found in the roots, tannin, *Derris red*, and a glucoside, *Derrin* (Bocquillon).

[Photo by G. Rickaut.

FIG. 54.—*Clitoria ternatea.*

Desmodium gangeticum (Shrub).—In India the whole of the plant is used in the form of a decoction in cases of fever and catarrh (Achart).

Desmodium cæspitosum (Shrub).—Diuretic and cooling. Used for dysentery (Daruty).

Desmodium triflorum (Shrub).—Depurative, laxative, anti-herpetic. Pulmonary diseases (Daruty).

Erythrina indica (Tree). The bark is anthelminthic and astringent; the flowers are bechic and good for affections of the chest. The active principle is *Erythrin* (Daruty). In India the leaves and roots are used in treating fevers.

Erythrina Corallodendron (Shrub).—According to the researches of Rochefontaine and Rey, the bark of the stem contains an alkaloid which acts upon the central nervous system without affecting the motor nerves and muscular contractility. Professor Rio de la Loza has isolated an alkaloid, *Erythrocoralloidin*. In South America the bark is in general use as a narcotic and sedative (Bocquillon).

Erythrina fusca (Shrub). A decoction of the bark is used in treating intermittent fevers. The bruised leaves serve for cleansing putrid ulcers. When applied locally they are anti-odontalgic. Similar properties are attributed to *E. corallodendron* (Lanessan).

Euchresta Horsfieldii (Shrub). According to Boorsma the seeds contain an alkaloid similar to *Cystisin*. They are used mixed with lemon juice for the bites of poisonous animals. Dr. Horsfield says this drug is a very good emetic (Bocquillon).

Flemingia Grahamiana (Shrub).—In India and West Africa this plant is used, externally, for skin diseases. It is used internally as a purgative and as a specific for colds. It contains a red colouring matter which is highly esteemed; this is a resin called *Flemingin* (Bocquillon).

Genista tinctoria (Shrub). Dyer's green-weed is used for cases of madness. A decoction of the flowers of the broom has been used with success in a few cases of albuminuria.

Glycyrrhiza glabra (Herb).—Liquorice root; is used for sweetening medicinal infusions.

Hedysarum semoides (Herb).—The root is tonic and stimulating.

Indigofera Anil (Shrub). In Mexico this plant is used as a vulnerary, stomachic, febrifuge, anti-spasmodic, and also as a diuretic. The seeds and roots when powdered form an insecticide (Bocquillon).

Indigofera trita (Shrub).—This plant contains a soapy principle in considerable quantities (Achart).

Indigofera aspalathoides (Shrub).—According to Ainslie, a decoction of the leaves is used as an emollient in leprous and cancerous diseases. The root, when chewed, is supposed to cure toothache (Achart).

Indigofera oligophylla (Shrub).—A decoction of this plant is used as a gargle in cases of mercurial salivation. Marvellous properties are attributed to it by the Hindus, who regard it as an antidote for every poison (Lanessan).

Indigofera polyphylla (Shrub).—The leaves, when pulverized, are used for inflammation of the liver. They are irritant and purgative; the root is said to have vermifugal properties (Lanessan).

Indigofera tinctoria (Shrub).—Emeto-cathartic, infantile convulsions; active principle *Indigo* (*Daruty*). The pulverized seed is used, applied locally, for ophthalmia, furuncles, and dropsy (Achart).

Indigofera argentea (Shrub).—Resolvent, venereal diseases; asthma (Daruty).

Indigofera paucifolia (Shrub).—Regarded by the Hindus as an antidote for all poisons; used as a gargle for mercurial salivation.

Lonchocarpus latifolius (Tree).—The leaves are irritant, purgative, and emetic. They are thrown into watercourses in order to stupefy fish (Lanessan).

Lonchocarpus sericeus (Tree).—The bark of this tree, which is very common near the sea, in Gaboon, is used as a laxative in infantile abdominal troubles. *Lonchocarpus formosianus* has similar properties (Lanessan).

Melilotus officinalis (Herb).—The flowers of *Melilotus officinalis* and of several closely related species contain a fragrant principle, *coumarin*. This is also present in the Tonka bean, which is used for scenting snuff.

Mucuna pruriens (Liane).—Aphrodisiacal, tonic, diuretic; hæmorrhoids, hemiplegia (Daruty).

Myroxylon toluiferum (Tree).—This tree, which grows in South America, furnishes the tolu balsam. As it occurs in commerce it is fairly firm, but it softens readily in the hand. It has an odour rather similar to that of vanilla; the taste is sweet and not unpleasant.

Tolu balsam has a soothing effect on coughs; it is also very useful for pulmonary catarrh, colds on the chest, laryngitis, and bronchitis. Owing to its refined and delicate odour tolu balsam is used in perfumery. It is soluble in alcohol, and forms the base of a perfume which enables it to retain its aromatic properties more readily.

Piscidia Erythrina (Tree).—Hart, in America, and Bruel and Tanret, in France, have isolated an alkaloid from the bark, giving crystallizable salts, which they have named *Piscidin*. According to Hart the formula is $C_{29}H_{24}O_8$.

Dr. Landowski has confirmed the sedative and soporific properties of this plant recorded by Professor Ott and Dr. Hamilton. Dr. Dujardin-Beaumetz has obtained remarkable results in the treatment of neuralgia of the lumbar and abdominal regions. Dr. Legoy has had good results in treating hysteria (gastric form), chronic alcoholism, chronic bronchitis, gastralgia, neuralgia, &c. (Bocquillon).

Pongamia glabra (Tree). The oil from the seeds is anti-soporific. Scabies, herpes, ulcers, rheumatism (Daruty).

Dymock says that this oil possesses all the advantages of iodoform and Goa powder without their drawbacks.

Psoralea corylifolia (Herb).- -The seeds are aromatic and bitter and are regarded as having stomachic properties. The Hindus make good use of them in diseases of the skin (Lanessan). The roots are emetic and the leaves purgative (Bocquillon).

Psoralea pentaphylla (Plant). -Dr. Lozano y Castro has discovered an alkaloid in the roots of this plant : *Psoralin*. In Mexico and the West Indies *Psoralea* is used in treating intermittent fevers.

Pterocarpus pallidus (Tree). -The wood of this tree is known in the Philippines as " nephretic wood." The natives regard it as an excellent remedy for stone in the bladder. It is used after being macerated in water.

Pterocarpus indicus (Tree). Astringent, odontalgic. The active principle is kinotannic acid (Daruty).

Rafnia amplexicaulis (Shrub). -A leguminous plant inhabiting Southern Africa which resembles somewhat the European brooms. It contains a sweet juice, similar to that of liquorice. Both it and the species *R. perfoliata* are used in medicine.

Robinia amara (Shrub).- Root extremely bitter. It is used for treating debility of the stomach. It is administered chiefly in the form of pills after first having been macerated in vinegar in order to remove the nauseous odour (Lanessan).

Sesbania ægyptiaca (Shrub). The leaves are applied in poultice form to furuncles; the seeds, when pulverized and mixed with flour, are used for irritation (Lanessan).

Tephrosia purpurea (Plant). Root bitter, used as a decoction in dysentery.

Tephrosia toxicaria (Plant).- The natives of Guiana, the West Indies and Tahiti formerly used the leaves for poisoning watercourses. The leaves are employed in medicine in a similar way to digitalis; the roots, which are purgative, are used for hæmorrhoids.

Trigonella Fœnum-græcum (Herb).- Cultivated in Abyssinia. The seeds are crushed and used for making soothing and resolvent poultices. Mixed with water they yield an abundant mucilage. They are regarded as having tonic, emollient, and vermifugal properties.

[Photo by G. Ribaut.

FIG. 55.—Leaves and pods of *Pongamia glabra*.

CÆSALPINIEÆ.

Andira inermis (Tree).—The seeds contain a bitter principle which gives them very marked emetic and anthelminthic properties. The bark is vermifugal, but large doses are dangerous; the flavour is bitter (Lanessan). Dr. Schœer has found an alkaloid, *Berberin;* and a glucoside, *Andirin* (Bocquillon).

Afzelia bijuga (Tree).—The fruit is acid and laxative, and is in great demand among the natives (Lanessan).

Bauhinia purpurea (Tree). The root is carminative, the flowers laxative. The bark, roots and flowers, when mixed with rice-water, are used in poultice form as a maturant (Lanessan).

Bauhinia reticulata (Tree).—The leaves are employed as an expectorant. The bark, which has a textile value, is astringent and is administered for diarrhœa and chronic dysentery. The leaves exude gum (Lanessan).

Bauhinia tomentosa (Shrub).—The dry leaves and buds are anti-dysenteric. A decoction of the root is employed for liver troubles and as an anthelminthic.

Bauhinia variegata (Tree).—The young rosy-white flowers are laxative and carminative (Lanessan). The leaves are used, after being dried, for pimples, and in the treatment of dysentery. A decoction of the bark of the root is recommended for diseases of the liver.

Brownea coccinea (Shrub).—The leaves are emollient. The flowers, when used as an infusion, are laxative and cooling (Lanessan).

Bowdichia major (Tree). Largely used in Brazil for rheumatism.

Bowdichia virgilioides (Tree).—This plant yields a bark called *écorce d'alcornoque,* which is in great repute for medicinal purposes in South America.

Cassia fistula (Tree).—In the pod of *Cassia fistula* is found a pulp coating all the partitions, the taste of which slightly resembles that of liquorice. This pulp is laxative. The active principle is *cathartic acid.*

Cassia occidentalis (Shrub).—The various portions of this very widely distributed plant are purgative; the roasted seeds are used for malaria. In Réunion it is employed for stomach troubles and asthma. The active principle is a fatty oil (Daruty). The root is tonic and diuretic. The leaves are febrifuge and anti-periodic. In Réunion the poorer classes mix the seeds with coffee.

Cassia moschata (Shrub).—The pod contains a pulp with purgative properties.

Cassia Tora (Shrub). Aperient; anti-hysteritic, detergent, and anti-herpetic (Daruty).

[Photo by G. Rihaut]

FIG. 56.—Branches of *Cassia occidentalis*.

Cassia Absus (Shrub). Seeds used for ophthalmia.

Cassia alata (Shrub).—Depuratory, purgative, anti-herpetic. The seeds are vermifugal (Daruty).

The active principle is *chrysophanic acid*. The juice of the leaves mixed with lemon-juice is a very good remedy for diseases of the skin. The Indians regard every portion of the plant as being an excellent antidote for snake-poison.

Cassia brasiliana (Shrub).—Contains a bitter and unpleasant pulp employed as a laxative or purgative (Lanessan).

Cassia chamæcrista (Herb). The leaves are purgative.

Cassia emarginata (Shrub). The fruit is purgative.

Cassia decipiens (Shrub).—The fruit is purgative.

Cassia elongata (Shrub). The leaves are purgative. The senna variety is known as Tinnevelly senna. English doctors regard this senna as being of superior quality.

Cassia glauca (Shrub).—The seeds are used for gout and diabetes. The leaves, when pounded with sugar and milk, are recommended for blennorrhagia (Lanessan).

Cassia biflora (Shrub). Anti-syphilitic.

Cassia hirsuta (Shrub). Anti-syphilitic and febrifuge.

Cassia Sophora (Shrub). The leaves, bark and seeds are used as a cathartic and as an anti-herpetic.

Cassia obtusa (Shrub). A species of senna, fairly common in the neighbourhood of Pondicherry. It is used by the natives as a substitute for the officinal senna (Arhart).

Cassia acutifolia (Shrub). The leaves of this variety are known in pharmacy as senna, and the fruit is termed senna-pod. Senna is an extremely valuable purgative and is used either alone, or with manna or rhubarb, in conjunction with sulphate of soda.

Cassia angustifolia (Shrub). *Cassia obovata* (Herb). These species also furnish senna.

Cassia auriculata (Shrub). In Egypt the seeds are a popular remedy for eye troubles of an inflammatory nature (Bocquillon).

In Ceylon the dried leaves are used as a substitute for tea (Macmillan).

Cæsalpinia Bonducella (Climbing Shrub). The seeds contain an active resin, *Bonducin*. They are bitter, febrifuge, astringent, and tonic. The leaves are emmenagogic. The root is used for curing snake bites. This plant is distributed throughout the tropical zone and is commonly known as *Cadoque*.

Cæsalpinia Sappan (Climbing Shrub).—Emmenagogic, anti-catamenial.—The active principle is *Brasilin* (Daruty).

Copaifera guianensis (Tree).—The oleo-resin, known as *Copahu balsam*, is extracted from the trunk by means of incisions. It is very largely employed for gonorrhœa.

This balsam is also obtained from the following varieties: *C. officinalis*, *C. nitida*, *C. Martii*, *C. coriacea*, *C. Beyrichii*, &c. This

[*Photo by Desruisseaux*.

FIG. 57.—*Cæsalpinia Bonducella*. Stems and fruit

oleo-resin contains copahu oil, from which it derives its odour, and *copahuvic acid*.

Cynometra ramiflora (Tree).—This plant is very bitter; the fruit is not edible. In India an oil is abstracted which is used for scabies and other diseases of the skin.

The roots are purgative (Lanessan).

Dialium nitidum (Tree).—The leaves, used as an infusion, are sudorific (Lanessan).

Eperua falcata (Tree).—The bark is bitter and is used by the Indians as an emetic. The oil known as *Woapa* is extracted from the trunk (Lanessan).

Erythophleum guineense (Tree).—A large tree which may attain a height of 35 metres. The bark, wood, leaves and fruit all contain an extremely violent poison, which is said to contain *erythrophlein*. The natives use it in ascertaining the judgments of Providence in a form of trial by ordeal.

Dr. Dujardin Beaumetz believes this alkaloid to have the same properties as digitalis, *i.e.*, a strengthening effect on the heart and also diuretic properties. It strengthens and soothes the action of the heart (Pennetier and Bocquillon). *Erythrophleum couminga*, common in Madagascar and the Seychelles, has similar properties.

Guillandina gemina (Shrub).—The leaves are emmenagogic; the root has an astringent action in dysentery (Lanessan).

Hæmatoxylon Campechianum (Tree).—The wood is astringent and antiseptic; the flowers are good for chest troubles. The active principle is *hæmatoxylin*. Diarrhœa, bronchitis (Daruty).

Hymenæa Courbaril (Tree).—A decoction of the bark is used internally as a vermifuge (Lanessan). A fluid extract formed from the bark is a good arterial sedative and is used as an astringent in cases of hæmaturia (Bocqaillon).

Hymenæa stilbocarpa (Tree).—This tree is commonly known as *Jatahy*. It yields pods containing a pulp which makes a syrup that is very good for coughs.

Jonesia Asoca (Tree).—Anti-menorrhagic (Daruty).

Pahudia cochinchinensis (Tree).—The seed coats are used in place of areca nut in the masticatory composed of lime and betel (Lanessan).

Parkinsonia aculeata (Tree).—This plant is used as a febrifuge and also as an aseptic.

Poinciana regia (Tree). Anti-rheumatic (Daruty).

Poinciana pulcherrima (Trailing Shrub).—The bark is emmenagogic, energetic and abortive. The flowers are good for chest complaints and are also febrifugal (Daruty).

The root is bitter and poisonous (Achart).

Saraca indica (Tree). According to Dymock, the bark is used a great deal in India for uterine troubles and especially for treating menorrhagia.

Sebipira major (Plant).—This plant is known in Brazil as *sicopira*. M. A. Petit has abstracted an alkaloid, *sicoporin*, which is numbing and mydriatic in action.

A decoction of the wood is employed in Brazil for syphilis. The root is used for diseases of the skin, rheumatism, &c.

The gum which flows from the tree is prescribed as an emollient in cases of diarrhœa. The juice of the bark is used in the fresh state for stomach troubles.

Tamarindus indica (Tree).—The fruit contains an acid pulp with a slightly laxative action. The pulp contains tartaric, citric, and acetic acids, sugar and pectines.

Vatærea guæanensis (Tree).—This plant, commonly known as *herpetic wood*, yields seeds which, when grated and mixed with vinegar, are employed in Guiana for curing herpes.

MIMOSEÆ.

Acacia Catechu (Tree).—This inhabitant of India and Africa is the source of the "cutch" so largely used as an astringent in medicine.

Acacia Farnesiana (Tree).—The leaves are used for diseases of the bladder.

Acacia odoratissima (Tree).—The bark is considered a good remedy for ulcers (Daruty).

Acacia arabica (Tree).—Indian doctors regard this plant as a powerful tonic and prescribe a decoction for washing nasty wounds. The ash of the leaves, mixed with coco-nut oil, is a remedy for scabies (Achart).

Acacia ruguta (Liane).—The pods of this liane contain *saponin* and give, when mixed with water, a soapy emulsion which the Hindus and Mussulmans employ for washing their heads and for clearing their hair of the oil they use (Achart).

Acacia leucophlœa (Tree).—The bark is astringent and enters into the preparation of *arrak patté*, a spirituous drink (Achart).

Adenanthera pavonina (Tree).—Astringent, detergent. The bark is used in the form of a gargle for herpetic and tonsillar quinsy (Daruty).

Albizzia Lebbek (Tree).—The leaves are used in poultice form for quinsy and also for bruises (Daruty).

Albizzia amara (Tree).—The leaflets are sold in the bazaars under the name of *Arapou* (Indies) and are used by the Indians instead of soap, especially for washing the head (Achart).

Albizzia Lophanta (Tree).—The root of this small tree is rich in *saponin*.

Albizzia anthelmintica (Plant).—The bark of the *Mousséna*, the common name for this plant, is considered in Abyssinia to be a more active remedy for tapeworm than *Kousso*. Thiel has abstracted a glucoside which he calls *mousséniin* (*Bocquillon*).

Calliandra Houstoni (Plant).—The Mexican *Pambotano.* The bark, which is a bitter tonic of the highest order, is used for fevers. According to an analysis by Dr. Bocquillon, it contains no alkaloid.

Entada gigalobium (Liane).—In Martinique the common names for this plant are *Climbing root, St. Thomas's Heart, Liane à bœuf.*

The seed has febrifugal and anthelminthic properties. M. A. Petit has found a glucoside, *saponin*, resin, fixed oil and gallic acid.

The seed is also in demand for snake bites (Bocquillon).

Entada scandens (Liane).—This plant is known as *Liane sabre.* The seeds are used in India as an emetic. A mucilaginous substance is found in the unripe fruit which is used in India for preparing a hair-wash.

Mimosa pudica (Shrub).—According to Daruty, this is a diuretic and a sedative and is to be prescribed for gravel and infantile convulsions.

Prosopis alba (Tree).—This is used in South America for treating catarrhal troubles. The bark is employed in the form of a decoction, the flavour of which is bitter and the smell similar to that of fenugreek.

Spirolobium australe (Tree). The fruit of this plant has an astringent action, and is employed, in the form of an aqueous infusion, internally and externally, for treating diarrhœa and blennorrhagia. It is also said to have abortive properties. It is known in the Argentine as *Pata de Galle* (Bocquillon).

Stryphnodendron polyphyllum (Tree).—This plant is known in Brazil as *Casca de Barbatimao.*

Drs. Peiscoto and Bocquillon prescribe a decoction of the bark, or else the powdered bark, in the form of a poultice, for stimulating indolent ulcers. The powder taken in the form of snuff is good for stopping bleeding from the nose (Bocquillon).

Tetrapleura Thonningii (Tree).—A decoction of the bark is used as an emetic; the fruit is used for fumigating purposes and as a febrifuge (Lanessan).

CHAPTER XV.

LEGUMINOSÆ USED FOR TEXTILE PURPOSES.

ONLY a few plants among the Leguminosæ are of use for textile purposes.

The chief species is *Crotalaria juncea,* but numerous other species furnish fibres which, though not of any great commercial value, still serve a number of useful purposes in those localities where they occur. The greater number of these plants are found in India, and the natives have turned them to excellent account.

In Australia it is chiefly the acacias which have shown the most useful qualities. These plants occur in many other parts of the Tropics, and might be turned to equally good account in spots where they are sufficiently numerous to allow of profitable exploitation.

We will restrict ourselves to a brief note on each species, with the exception of *Crotalaria juncea,* the fibre of which occurs in commerce under the name of Sun Hemp, and which merits more attention.

PAPILIONACEÆ.

Æschynomene aspera (Tree). The wood is used for making mats. In India the pith of *Æschynomene indica* is employed for manufacturing baskets and various other similar articles.

Butea frondosa (Tree).—The bark of the roots is used for textile purposes.

Crotalaria juncea (Shrub).—This plant is subject to intensive cultivation in different parts of Southern Asia, and especially in India, for the sake of the fibre extracted from its stem. The stems are "retted" by immersing for four or five days in water, the bark is then removed by beating, without breaking the fibres, the removal of the last portions being accomplished by beating against the water. After drying, the fibres are separated. Those obtained in this way

[*Photo by G. Rihaut.*

FIG. 58.—*Crotalaria juncea.* Stems and fruit.

are very strong and are used in the manufacture of ropes and sails. Their commercial value is fairly high.

The stems are harvested when in flower, being cut down to the soil surface. The method varies in different localities; sometimes the pods are allowed to ripen and the plant is then pulled up. Mollison says that the plants yield good fibres when in flower, but better still when mature.

The stems are allowed to remain on the fields till they wither in order to get rid of the leaves before "retting," they are then done up in bundles of one hundred and stored till completely dry. "Retting" is carried out for five days in deep, stagnant water, and is accomplished quicker in this way than in running water.

Mollison has experimentally established the yield per hectare. The crop of dry stems weighs 14,880 lb. and these give 1,230 lb. of good fibre. Mukerji gives an average yield to be 1,520 lb., with limits of 470 to 2,840 lb.

The fibre can be used for the same purposes as that of Sisal. In India it is chiefly used, after tanning, for making fishing nets.

During the last twenty-seven years the export from India has increased considerably.

Crotalaria laburnifolia (Shrub).—This species is very widely distributed in India and is used for the manufacture of paper. In Queensland it grows by the water side.

Cajanus flavus (Shrub).—An annual plant very largely cultivated in Southern India. The stems are used for making mats and baskets.

Desmodium tiliæfolium (Shrub).—The fibrous bark of this plant is used in India for manufacturing ropes and baskets.

Derris uliginosa (Climbing Shrub).—The stems of this climbing shrub are used for making log-lines for vessels. It occurs in numerous localities in India, and also in Queensland and Northern Australia.

Herminiera Elaphroxylon (Tree).—A small tree of aquatic habitat occurring in tropical Africa. It is used for making hats.

Dioclea reflexa (Shrub).—An Indian plant of woody nature.

Indigofera atropurpurea (Shrub).—Extensively used for manufacturing baskets and ropes of various kinds.

Melilotus alba (Herb).—The fibres of the cortex may be used for manufacturing paper pulp.

Mastersia assamica (Shrub).—An Indian plant of woody nature.

Pachyrhizus montanus (Liane).—In New Caledonia the fibres of this species are used for making fishing nets of particularly good quality.

Psoralea Archeri (Shrub).—This leguminous plant occurs in North Queensland, where, according to Palmer, it is known as *Wommo*, the name given by the natives along the Cloncurry river. They use it to manufacture ropes; for this purpose the plant is pulled up,

soaked in water for a few hours, and then dried. The bark is removed and the fibre used for making strong cords and ropes (Northern Australia).

Several indigenous species are found in tropical Africa : *Psoralea plicata, P. obtusifolia, P. andongensis.* It is possible that these species have the same properties as that quoted.

Psoralea patens (Shrub).—This species of *Psoralea* is found throughout Australia, but not in Tasmania. According to Bancroft and Bailey, this plant reaches a height of 2 metres in Western Queensland and yields a strong, tough fibre.

Sesbania aculeata (Shrub).—In the "Treasury of Botany" we find that this plant is cultivated in India for the sake of its fibre, which, though somewhat coarse, is very strong and very durable in water. It is used for manufacturing nets and ropes unaffected by water. This species is found in Australia, Tropical Africa, and the West Indies.

Sesbania cannabina (Shrub).—Cultivated in Asia for the sake of its fibre.

Sesbania ægyptiaca (Shrub). The bark is used for making coarse rope.

Spatolobus Roxburghii (Shrub).—A coarse fibre is extracted from this plant in India.

CÆSALPINIEÆ.

Bauhinia tomentosa (Shrub).—This plant, which is a native of Tropical Africa, has been introduced into India, where the bark is used for manufacturing ropes.

Bauhinia reticulata (Shrub). The bark produces very stout fibre. A native of Tropical Africa.

Bauhinia macrostachya (Shrub).—The bark of this species and that of *Bauhinia Vahlii* is used for making gun fuses.

Bauhinia racemosa (Shrub).—A climbing shrub, the fibres of which are used to make ropes; these latter, however, have little durability in water.

Bauhinia scandens (Shrub).—In India this plant furnishes a textile substance, known as *Malos* or *Apta,* which is used for manufacturing cords, nets, &c.

Bauhinia Vahlii (Shrub).—The fibre obtained from the bark is used to manufacture extremely tough rope. It is one of the most useful varieties in India.

Bauhinia variegata (Tree).—The bark produces a fibre of good quality.

Hardwickia binata (Tree).—In India the stringy bark of this tree is used for making rope.

Parkinsonia aculeata (Plant).—The fibres are used for manufacturing paper.

MIMOSEÆ.

Acacia arabica (Tree).—The young stems are used for manufacturing baskets and fishing nets. Coarse rope is also made from the fibres of the bark.

Acacia aulacocarpa (Shrub), **Acacia complanata** (Shrub).—Both these plants yield fibre.

Acacia eburnea (Shrub).—The bark contains a very tough fibre, which is used for making large fishing nets and coarse rope.

Acacia leucophlœa (Tree).—The bark yields a very strong fibre used for fishing nets.

Acacia linifolia (Shrub).—This plant yields fibre.

Acacia melanoxylon (Shrub).—This variety is very common in Australia and the shavings of this and other species are used for making hats.

Numerous other acacias might be used for manufacturing paper more or less coarse in quality.

CHAPTER XVI.

VARIOUS LEGUMINOSÆ.

THERE is great diversity of character among the members of the family of the Leguminosæ and species occur which yield the most varied products. There are, for instance, some very interesting melliferous plants; trees the leaves of which serve both as food for man and fodder for beast; seeds yielding perfume; scented resins and numerous other products apart from those mentioned in the foregoing chapters, and the peas which have already been discussed at some length.

In view of the very considerable interest attaching to these plants, a list is given of the various species. Possibly a few may have escaped our notice.

PAPILIONACEÆ.

Apios tuberosa (Liane).—A twining plant which yields an edible tubercle of slow growth.

Castanospermum australe (Tree).—A large tree, a native of Australia, which has spread to the Tropics. It bears pods which average 365 grm. in weight and which contain two to four seeds.

These seeds are edible when roasted and have a fairly pleasant flavour.

According to our experiments the pods weigh from 250 to 450 grm. and give a proportion of :—

Seeds	32·4 per cent.
Thick coats	12·6 ,,
Husks	55·0 ,,
	100·0

The composition of the seeds is as follows :—

	In 100 parts of dry matter	In 100 parts of seed
Water	—	87·10
Ash	3·57	0·46
Cellulose	5·64	0·73
Fat	1·76	0·23
Sugars	29·84	3·85
Non-nitrogenous matter	43·32	5·58
Nitrogenous matter	15·87	2·05
	100·00	100·00
Nitrogen	2·54	0·33

[Photo by G. Rehaut.

FIG. 59.—*Castanospermum australe.*

The seed coats and husks contain :—

	Seed coats		Husks	
	In 100 parts of dry matter	In 100 parts of natural substance	In 100 parts of dry matter	In 100 parts of natural substance
Water		80·4	—	81·4
Ash	2·65	0·52	2·73	0·51
Nitrogen	2·32	0·45	1·42	0·26

Canavalia gladiata.—According to Firminger, Europeans consider this to be the best Indian legume. It is a very sturdy climbing shrub and bears pods 22·5 cm. long by 3 cm. broad. These pods are eaten green, like haricot beans, and have a distinctive flavour which is very pleasant.

Coumarouna odorata (Tree).—This tree yields a seed, called the *Tonka bean,* which contains *coumarin.* This is a volatile principle with a strong odour of newly cut hay. It is used in perfumery.

Other varieties also furnish perfumed seeds. *Dipteryx oppositifolia*, from Cayenne and Brazil; *D. pteropus*, from Brazil; *D. Eboensis,* from Mosquito, has a seed identical with that of *D. odorata*, but it has no perfume. It contains a thick oil, which the natives extract and use for dressing their hair.

Dolichos bracteata.—A trailing pea which bears purple flowers set close together. The pods are about 3 in. long, and are eaten boiled while in the green state.

Dolichos Ahipa. A perennial liane from Peru. The roots are thick, fleshy, and fusiform in shape. The natives use them for food.

Dolichos tablavia (Herb).—The plant is eaten green.

Erythrina indica (Tree).—In Ceylon the young, tender leaves are eaten with curry, like the leaves of many other plants. This tree is of general occurrence in the Tropics.

Inocarpus edulis (Tree).—A tree of no great height belonging to the islands of the Pacific. The large, fleshy seeds, which are contained in a stout pod, are edible, and are said to be an important native food. When boiled or roasted these seeds have a good flavour.

Kennedya prostrata (Shrub). The leaves of this small trailing plant were used by the early colonists as a substitute for tea, and, according to Wilhelmi, had a very agreeable flavour.

Mucuna cochinchinensis (Liane).—A climbing plant with edible seeds and pods.

Mucuna gigantea (Liane), **Mucuna monosperma** (Liane).—The seeds are eaten by the natives.

Mucuna nivea.—A climbing pea with stout pods containing black oval seeds. In Ceylon these seeds are eaten by the natives. In India the pod is used as well, after the outer skin has been removed. Roxburgh says that it is an excellent table vegetable.

As usual with the Leguminosæ, the seeds are sown at the beginning of the rainy season.

Oxylobium ellipticum (Shrub).—Mr. Hammond writes from Bry Bay, in Australia, that he has never seen bees in such large numbers on any other flower, except possibly on that of maize.

Oxylobium trilobatum (Shrub).—This shrub is regarded in Australia as a melliferous plant.

Phaseolus calcaratus.—An Indian bean, the composition of which is as follows:—

Water	10·00 per cent.
Ash	3·90 ,,
Cellulose	5·30 ,,
Fat	1·05 ,,
Non-nitrogenous matter	55·96 ,,
Nitrogenous matter	23·79 ,,
	100·00

The average weight of 100 seeds is 8·89 grm. (Balland).

Phaseolus coccineus.—There are two varieties of this bean: one with scarlet flowers, and another with perfectly white flowers. It serves as an ornamental plant, and has a somewhat tuberous perennial root. The seeds are edible, especially those of the white variety, which is also more productive.

Phaseolus farinosus.—An Indian bean, an analysis of which is given by M. Balland.

Water	9·40 per cent.
Ash	4·50 ,,
Cellulose	5·80 ,,
Fat	1·06 ,,
Non-nitrogenous matter	54·99 ,,
Nitrogenous matter	24·25 ,,
	100·00

Average weight of 100 seeds, 11·30 grm.

Pisum arvense.—This field pea is cultivated on a large scale for the sake of its seeds and sometimes as a forage crop.

It is particularly widely distributed in India and is cultivated over large areas. The seed is used for food. Its composition is as follows:—

Water	10·12 per cent.
Ash	3·25 ,,
Cellulose	4·79 ,,
Fat	1·21 ,,
Non-nitrogenous matter	58·63 ,,
Nitrogenous matter	22·00 ,,
	100·00
Nitrogen	3·52 per cent.
Protein nitrogen	3·20 ,,

This analysis is by Dr. Leather.

Mr. Watt says it is a very good fodder, but growers generally prefer to leave it for seed.

Psoralea brachiata (Shrub).—This legume has farinaceous roots, which are eaten cooked.

Pultenæa parviflora (Shrub).—A melliferous Australian plant.

Pueraria Thunbergiana (Climbing Shrub).—A perennial legume from Japan. It produces a feculent edible root.

Pueraria tuberosa (Climbing Shrub).—A variety from Southern Asia, which produces large edible tubercles.

Sesbania grandiflora (Shrub). According to Roxburgh, the leaves and young pods might well be used instead of spinach.

Sesbania brachycarpa (Shrub).—In Australia the pods are picked when green and eaten as a vegetable.

Trigonella Fœnum-græcum (Herb).—The whole of the plant is eaten by the Hindus. It has a pungent odour. The seeds are used for seasoning food dishes.

CÆSALPINIEÆ.

Afzelia africana (Tree).—The seed coat has an agreeable flavour. Negroes and also monkeys are very fond of them.

Bauhinia purpurea (Tree).—The flowers of this species are eaten with curry or mixed with various other sauces.

Bauhinia Vahlii (Shrub).—The seeds are eaten raw or roasted. The young shoots of the variety *Bauhinia variegata* are cooked and eaten by the mountain tribesmen.

Bauhinia Carronii (Shrub).—The flowers secrete a clear honey, which the blacks press out with the fingers and eat; they also put the flowers in water and drink the mixture (Palmer).

Bauhinia malabarica (Shrub). The leaves are used for food in Burmah and Bombay, and the young buds are eaten as a vegetable.

Cæsalpinia digyna (Tree).—Roxburgh has named this species *Cæsalpinia oleosperma* on account of the oil contained in the seed, which is used as an illuminant in certain parts of India.

Cynometra cauliflora (Tree).—This is a tree of tufted growth which bears very wrinkled pods only containing one seed. It bears quite close to the ground all round the trunk. It has an excellent flavour, and is eaten by the natives of India and the Malay Archipelago.

Detarium senegalense (Tree).—The flesh of this fruit is floury and greenish in colour. The negroes eat a large quantity. A closely allied variety occurs which is dangerous.

Dialium nitidum (Tree).—The fruit is a rounded berry, somewhat compressed, black and velvety in appearance, and contains a floury pulp. The pleasant and somewhat acid flavour of this pulp makes it a favourite among the negroes.

Hymenæa Courbaril (Tree).—The pod contains about 20 to 30 sweet, starchy seeds. They may be used as food for man, and especially for children, without any previous preparation (Decaux, *Le Naturaliste*, 1891).

Tamarindus indica (Tree).—The tamarind is a fine tree which sometimes attains large dimensions. It is distributed throughout the Tropics, and especially in India, Africa, Northern Australia, &c. In

[*Sketch by P. A. Desruisseaux.*

FIG. 60.—Flower of Tamarind (natural size).

India this plant is the subject of a fairly important trade on account of the pulp which surrounds the seeds.

It produces pods which ripen during the dry season. The husk, which is very fibrous, contains a pulp which is both sweet and acid at once. In India it is estimated that a large tree may produce 200 to 250 kilos of fruit.

The proportion of seeds in the fruit is 35 to 36 per cent., of pulp 53 to 56 per cent., and of husk 10 to 12 per cent.

The seeds, which average 0·760 grm. in weight, are eaten by certain Indian tribes. They are either dried in the sun or lightly roasted and subsequently reduced to flour. This flour is used to make cakes or sometimes even mixed with corn to make bread. The seeds may have some harmful effect if they are not completely separated from their husks and seed-coats, which contain certain astringent properties.

The seeds, when pounded and boiled, form an adhesive mucilage used for binding and other purposes.

Hooper gives the composition of the seeds :—

	In 100 parts of husks	In 100 parts of seed
Water	10·50	9·35
Ash	2·55	2·45
Cellulose	5·36	0·66
Fat	4·50	6·60
Non-nitrogenous matter	63·22	62·88
Nitrogenous matter	13·87	18·06
	100·00	100·00
Nitrogen	2·22	2·89
Phosphoric acid	0·40	0·55

The pulp has a more general use. It is used chiefly for seasoning certain Indian dishes, such as curry, and in the preparation of certain

[*Photo by Desruisseaux.*

FIG. 61.—*Tamarindus indica.* Stems and fruit.

sauces. On account of its acidity it may replace tomato. This pulp is extracted from the pods; it is partially dried and pressed into masses, which are cut up into tablets for export.

It is then further sectioned and sold in small balls weighing 36 to 40 grm. Prepared in this way we have found its composition to be as follows :—

	In 100 parts of dry matter	In 100 parts of pulp
Water	— ...	31·20
Acidity expressed in SO_3	7·97 ...	5·48
Sugars	21·53 ...	14·81
Ash	5·31 ...	3·65
Nitrogenous matter	3·62 ...	2·50
Nitrogen	0·58 ...	0·40

[*Photo by Desruisseaux.*

FIG. 62.– *Tamarindus indica* (Tamarind in Anjouan).

M. Balland gives an analysis in which the figures differ considerably from our own :—

	In the normal state In 100 parts	In the dry state In 100 parts
Water	25·00 ...	—
Ash	3·50 ...	4·67
Cellulose	8·00 ...	10 67
Fat	4·60 ...	6·13
Sugars	42·60 ...	56·80
Non-nitrogenous matter	12·94 ...	17·25
Nitrogenous matter	3·36 ...	4·48
	100·00	100·00

Cooked with sugar this pulp keeps very well and, diluted with water, forms a very pleasant and refreshing drink.

Taken in certain quantities it has a slightly purgative action and is therefore used in medicine.

The leaves, in view of their natural acidity, are of no use for fodder purposes.

MIMOSEÆ.

Acacia sp. (Tree).—Bees are very fond of the flowers of this species. Their cultivation is strongly recommended in Australia.

Acacia Julibrissin (Tree). A somewhat uncommon tree with aromatic leaves used as a kind of tea.

Acacia myrtifolia (Tree).—According to Wilhelmi, the leaves of this plant have been used to make a bitter beverage, a possible substitute for hops in Australia.

Inga dulcis (Tree). The fruit of *Inga dulcis* is edible, and contains seeds surrounded by a sweet pulp.

Inga Feuillei (Tree). This plant, a native of Peru, is cultivated in the gardens and general neighbourhood of Lima. It is called *Pacay*, and the natives eat the pulp of the pods, these latter being sometimes as much as 2 ft. long.

Inga spectabilis (Tree).—This large tree, known as *Guavo*, occurs on the Isthmus of Panama. It is generally cultivated for the sake of the pods, which are edible. The same applies to those portions of New Granada where it occurs.

The pulp has an extremely sweet and agreeable flavour.

Prosopis juliflora (Tree). The "Algaroba" is a plant belonging to tropical and sub-tropical countries. It grows very well at low altitudes, but it extends from sea-level to extremely high altitudes. Though acclimatized at a height of even 2,000 ft., where it has been observed, its yield becomes smaller, and the best yields are obtained from plants grown almost at sea-level.

It occurs in largest numbers in South America and the West Indies. It has spread to a certain extent in all directions and is held in very high esteem.

In Hawaii Mr. Wilcox has carried out a very interesting research which has determined the uses to which this plant may be turned.

The pods are a first-class nutriment for animals and furnish a large quantity of honey. It is the most popular melliferous plant, and hives are placed around them.

It has been estimated that approximately 500,000 sacks of seeds are harvested annually in Hawaii. They are stored for horse and cattle feed.

The Algaroba also furnishes an excellent fuel. The small branches are used for making charcoal.

On account of their large proportion of sugar the pods may be used for manufacturing methylated spirit and vinegar.

These pods have the following composition :—

Water	15·26 per cent.
Ash	3·25 ,,
Cellulose	24·75 ,,
Fat	0·58 ,,
Non-nitrogenous matter	47·27 ,,
Nitrogenous matter	8·89 ,,
	100·00

The seeds give :—

Water	14·38 per cent.
Ash	4·44 ,,
Cellulose	6·84 ,,
Fat	3·94 ,,
Non-nitrogenous matter	36·78 ,,
Nitrogenous matter	33·62 ,,
	100·00

According to analysis by Sievert, these pods contain 25 to 28 per cent. of grape sugar, and 11 to 17 per cent. of starch.

This fruit is used for manufacturing a kind of frothy beer, called *Aloja*.

Other species of *Prosopis* are also held in some esteem; these are *P. glandulosa*, *P. pubescens*, *P. horrida*, *P. spicigera*, and several other species of the same genus are worth propagating.

Prosopis spicigera (Tree).—This is a variety of *Prosopis dulcis* with sweet farinaceous pods which are used for food in the North of India in times of famine. They are eaten either green or dry, raw or boiled with salt and onions.

Albizzia amara (Tree).—The so-called "Jyree tea" consists of a mixture of ordinary tea with the specially prepared leaves of this plant.

Mimosa abstergens (Shrub).—Leaves used for seasoning.

Mimosa pudica (Shrub).—The leaves occupy different positions day and night and react to the touch. Several other species are equally irritable to *Mimosa pudica*; they are *M. viva*, *M. casta*, *M. speciosa*, *M. asperata*.

The members of the Leguminosæ whose irritability approaches that of the sensitive species are *Smithia sensitiva*, *Æschynomene sensitiva*, *Æ. indica*, *Æ. pumila*, *Desmanthus stolonifer*.

Some very thorny and shrubby mimosas are used to make protective hedges; such are *M. rubricaulis* and *M. acanthocarpa*.

Neptunia oleracea (Herb).—This plant is cultivated, but it occurs wild as a floating plant in ponds and sluggish streams. The edible

portions, that is to say, the buds and young shoots, are used as a vegetable.

Parkia biglobosa (Tree).—This tree yields a straight elongated pod with a farinaceous pulp which is used to prepare a food and also a drink. The seeds are roasted like those of coffee. They are first broken up and allowed to ferment in water, they are then crushed and made into a flour, which is added to cooked meats as a condiment.

This flour is known as *Nété* flour, and the seeds by themselves, separated from their thin woody covering, are also used for food.

M. Balland gives the average weight of 100 seeds as 27 grm. The proportion of seeds is 70 per cent., and their composition is as follows :—

Water	5·70 per cent.
Ash	4·30 ,,
Cellulose	2·90 ,,
Fat	22·75 ,,
Sugars	12·60 ,,
Non-nitrogenous matter	15·54 ,,
Nitrogenous matter	36·21 ,,
	100·00

Nété flour contains a fairly high proportion of sugar :—

Water	9·90 per cent.
Ash	4·20 ,,
Cellulose	11·65 ,,
Fat	0·90 ,,
Sugars	31·25 ,,
Non-nitrogenous matter	38·47 ,,
Nitrogenous matter	3·63 ,,
	100·00

Parkia biglobosa is found throughout the African tropical belt.

Pentaclethra macrophylla (Tree).—The pod is about 1½ ft. long, compressed, and contains seeds 7 cm. long by 5 cm. broad.

The embryo contains 49 per cent. of a fatty, oily matter, which rapidly turns rancid. It is eaten by the blacks.

CHAPTER XVII.

ORNAMENTAL LEGUMINOSÆ.

PAPILIONACEÆ.

Abrus precatorius.—Native of India. Flower, pale blue. Climbing herb.
Adenocarpus Frankenioides.—Tropical Africa. Fl. yellow. Shrub.
Adesmia viscosa.—Chili. Fl. yellow. Under-shrub.
„ **Loudonia.**—Chili.—Fl. yellow. Under-shrub.
„ **microphylla.**—Chili. Fl. yellow. Under-shrub.
„ **glutinosa.**—Chili. Fl. yellow. Under-shrub.
„ **pendula.**—Montevideo. Fl. yellow. Herb.
Agati grandiflora.—East Indies. Fl. pale red or white. Tree.
Alhagi maurorum. Egypt. Fl. red. Shrub.
Alysicarpus vaginalis.—East Indies. Fl. red. Herb.
Amicia zygomeris.—Mexico. Fl. yellow. Shrub.
Amorpha fructicosa.—Carolina. Fl. purple. Shrub.
„ **herbacea.** Carolina. Fl. blue. Shrub.
Anagyris latifolia.—Teneriffe. Fl. yellow. Shrub.
Andira inermis. San Domingo. Fl. purple. Tree.
Anthyllis onobrychioides.—Spain. Fl. yellow. Perennial, herbaceous stems.
„ **heterophylla.**—Portugal. Fl. rose. Shrub.
Aotus villosa.—Australia. Fl. yellow. Shrub.
Apios tuberosa.—Pennsylvania. Fl. dark purple and rose flesh colour. Twining herb.
Argyrolobium uniflorum.—Sinai. Fl. yellow. Shrub.
Arthrolobium durum.—Spain. Fl. yellow. Herb.
Aspalathus ciliatus. Cape of Good Hope. Fl. yellow. Shrub.
„ **araneosa.**—Cape of Good Hope. Fl. yellow. Shrub.
„ **carnosa.**—Cape of Good Hope. Fl. yellow. Shrub.
Astragalus procumbens. Chili. Fl. light purple. Herb.
„ **stipulatus.**—Nepaul. Fl. greenish-white. Herb.
„ **reptans.**—Mexico. Fl. white. Herb.

Baptisia perfoliata.—Carolina and Georgia. Fl. yellow. Herb.
„ **lanceolata.**—Carolina and Georgia. Fl. yellow. Herb.
„ **Australis.**—West Carolina. Fl. blue. Herb.
„ **mollis.**—Carolina. Fl. blue. Herb.
„ **villosa.**—Virginia and Carolina. Fl. yellow. Herb.
„ **tinctoria.**—Canada and Carolina. Fl. yellow. Herb.
„ **alba.**—Virginia and Carolina. Fl. white. Herb.
Berbieria polyphylla.—Porto Rico. Fl. purple. Shrub.

Borbonia barbata.—Cape of Good Hope. Fl. yellow. Shrub.
,, **cordata.**—Cape of Good Hope. Fl. yellow. Shrub.
,, **ruscifolia.**—Cape of Good Hope. Fl. yellow. Shrub.
Bossiæa scolopendria.—Australia. Fl. yellow and purple. Tree.
,, **heterophylla.**—Australia. Fl. yellow and purple. Shrub.
,, **microphylla.**—Australia. Fl. yellow. Shrub.
,, **ensata.**—Australia. Fl. yellow. Shrub.
Brachysema latifolium.—Australia. Fl. flame-red. Climbing under-shrub.
,, **ondulatum.** New South Wales. Fl. yellow. Under-shrub with twining branches.
,, **Celsianum.**—Australia. Erect, sarmentous. Fl. dark blood-red. Under-shrub.
Butea frondosa. India. Fl. orange-red. Tree.

Cajanus bicolor. India. Fl. yellow and purple-brown. Shrub.
,, **flavus.** India. Fl. yellow. Plant.
Callistachys lanceolata.—Australia. Fl. yellow. Shrub.
,, **ovata.**—Australia. Fl. yellow. Shrub.
,, **lancifolia.**—Australia. Fl. yellow and red. Shrub.
,, **linearis.**—Australia. Fl. dull purple and violet. Shrub.
Calpurnia intrusa.—Cape of Good Hope. Fl. light-yellow. Shrub.
Carmichælia australe.—Australia. Fl. pinkish-blue. Shrub.
Castanospermum australe.—Australia. Fl. red. Tree.
Centrosema brazilianum.—Brazil. Fl. blue. Sarmentous shrub.
,, **virginianum.**—Brazil. Fl. blue and dark purple. Sarmentous shrub.
,, **Plumieri.**—Brazil. Fl. white and pinkish-purple. Sarmentous shrub.
Chorizema ilicifolia.—Australia. Fl. semi-yellow and purple. Under-shrub.
,, **ericoides.** Australia. Fl. semi-yellow and purple. Under-shrub.
,, **superba.**—Australia. Fl. semi-yellow and purple. Under-shrub.
,, **nana.** Australia. Fl. yellow and red. Shrub.
,, **varium.**—Fl. orange and red. Shrub.
,, **cordata.** Australia. Fl. red. Shrub.
,, **ovata.**—Australia. Fl. scarlet and yellow. Shrub.
,, **triangulare.**—Australia. Fl. scarlet and green. Shrub.
,, **rhombea.** Australia. Fl. saffron. Shrub.
,, **Henchmanni.**—Australia. Fl. purple and yellow. Shrub.
,, **spectabile.**—Australia. Fl. rose, yellow and purple. Shrub.
,, **platylobia.** Australia. Fl. yellow. Shrub.
Clianthus Dampieri.—Australia. Fl. a fine scarlet. Herb.
,, **puniceus.**—Australia. Fl. purple. Shrub.
Clitoria cajanæfolia.—Tropical America. Fl. pink and red. Herb.
,, **ternatea.**—India. Fl. blue. Climbing herb.
,, **heterophylla.** India. Fl. blue. Climbing herb.
Colutea frutescens.—Southern Africa. Fl. red, scarlet, white. Shrub.

[Photo by G. Réchaut.

FIG. 63.—Flowering branches of *Cassia aurea.*

Collæa pendula.—Cayenne. Fl. red. Shrub.
Coronilla pentaphylla.—Algeria. Fl. yellow. Shrub.
,, **cretica.**—Crete. Fl. white and red. Shrub.
Coursetia tomentosa. Peru. Fl. yellow. Shrub.
Crotalaria alata.—Nepal. Fl. pale yellow. Shrub.
,, **bracteata.**—East Indies. Fl. yellow. Shrub.
,, **Brownei.** Jamaica. Fl. yellow-brown striped. Shrub.
,, **capensis.**—Cape of Good Hope. Fl. yellow and purple. Shrub.
,, **cytisoides.**—Nepal. Fl. yellow. Shrub.
,, **juncea.** India. Fl. yellow. Shrub.
,, **laburnifolia.** Ceylon. Fl. pale yellow. Shrub.
,, **Novæ Hollandiæ.**—Australia. Fl. purple. Shrub.
,, **paniculata.** Java and China. Fl. yellow. Shrub.
,, **pendula.** Jamaica. Fl. yellow. Shrub.
,, **pulcherrima.** Mysore. Fl. yellow. Shrub.
,, **purpurascens.** Madagascar. Fl. purple. Shrub.
,, **purpurea.** Cape of Good Hope. Fl. dark purple. Shrub.
,, **pulchella.** Cape of Good Hope. Fl. yellow. Shrub.
,, **procumbens.** Mexico. Fl. yellow. Shrub.
,, **quinquefolia.** Madagascar. Fl. yellow. Shrub.
,, **retusa.** Mauritius. Fl. yellow. Shrub.
,, **semperflorens.** India. Fl. yellow. Shrub.
,, **spectabilis.**—East Indies. Fl. purple-brown. Shrub.
,, **tinifolia.**—Nepal. Fl. yellow. Shrub.
,, **verrucosa.**—East Indies. Fl. blue. Shrub.
Cyanospermum tomentosum. India. Fl. yellow. Twining undergrowth.
Cyclopia galioides. Cape of Good Hope. Fl. yellow. Shrub.
,, **genistoides.**—Cape of Good Hope. Fl. yellow. Shrub.
,, **latifolia.** Cape of Good Hope. Fl. yellow. Shrub.
Cytisus albus.—Portugal. Fl. white. Shrub.
,, **nubigenus.** Teneriffe. Fl. white. Shrub.
,, **proliferus.** Teneriffe. Fl. white. Herb.

Dalbergia scandens.—Coromandel. Fl. white. Sarmentous shrub.
Dalea alopecuroides. Louisiana. Fl. white and pale violet. Herb.
,, **leucostoma.** Mexico. Fl. yellow. Herb.
Daviesia longifolia. Australia. Fl. yellow and purple. Shrub.
Daubentonia punicea. Mexico. Fl. flame colour. Shrub.
Dillwynia floribunda. Australia. Fl. yellow. Shrub.
,, **glycinifolia.**—Australia. Fl. purple. Shrub.
,, **parvifolia.** Australia. Fl. white. Shrub.
,, **rudis.** Australia. Fl. yellow and purple. Shrub.
Dioclea glycinoides. New Granada. Fl. scarlet red. Shrub.
Dolichos lignosus. India. Fl. rose or purple. Liane.
Dorycnium herbaceum. Southern Europe. Fl. white. Herb.

Edwardsia grandiflora. New Zealand. Fl. yellow. Tree.
,, **chilensis.**—Chili. Fl. yellow. Tree.

Photo by G. Réhaut.

FIG. 64.—*Cassia fistula.*

Erythrina arborescens.—India. Fl. scarlet. Tree.
,, **carnea.** -Vera Cruz. Fl. pale rose. Tree.
,, **Crista Galli.**—Brazil. Fl. scarlet red. Tree.
,, **indica.**—India. Fl. red. Tree.
Eutaxia myrtifolia. Australia. Fl. yellow-gold. Shrub.
,, **pungens.**—Australia. Fl. yellow and dark orange. Shrub.
Eysenhardtia. -Mexico. Fl. white. Tree.

Fagelia butiminosa.—Cape of Good Hope. Fl. yellow and violet. Shrub.
Flemingia strobilifera. -India. Fl. pale yellow. Under-shrub.

Galega officinalis.—Southern Europe. Fl. blue and white. Herbaceous plant.
Genista aspalathoides.—Mauritania. Fl. yellow. Shrub.
,, **canariensis.** -North Africa. Fl. yellow. Shrub.
,, **Salzmanni.**—Corsica. Fl. yellow. Shrub.
Geoffræa violacea. Guiana. Fl. violet. Tree.
Gliricidia maculata.—Ceylon. Fl. rosy white. Shrub.
Gompholobium grandiflorum.- Australia. Fl. yellow. Shrub.
,, **Knightianum.** Australia. Fl. bluish. Shrub.
,, **venustum.**—Australia. Fl. purpurine. Shrub.
,, **versicolor.** Australia. Fl. yellowish-red. Shrub.
Goodia lotifolia.—Australia. Fl. yellow spotted with red. Shrub.
,, **pubescens.**—Australia. Fl. yellow spotted with red. Shrub.

Hardenbergia macrophylla.—Australia. Fl. vivid blue. Climbing shrub
,, **monophylla.**—Australia. Fl. violet blue. Climbing shrub.
,, **ovata.** Australia. Fl. purple. Climbing shrub.
Hovea longifolia.—Australia. Fl. violet. Shrub.
,, **pannosa.**—Australia. Fl. purple and yellow. Shrub.
,, **pungens.**—Australia. Fl. blue and white. Shrub.
,, **ramulosa.** Australia. Fl. pale blue. Shrub.

Indigofera australis. Australia. Fl. rose. Shrub.
,, **cytisoides.** -East Indies. Fl. purple. Shrub.
,, **denudata.** Cape of Good Hope. Fl. purple. Shrub.
,, **macrostachya.**—China. Fl. rose. Shrub.
,, **procumbens.** Cape of Good Hope. Fl. dark blue. Under-shrub.
,, **tinctoria.** Equatorial Africa and India. Fl. reddish. Shrub.

Jacksonia furcellata.- Australia. Fl. yellow. Small shrub.
,, **scoparia.** -Australia. Fl. yellow. Small shrub.

Kennedya Marryattæ. -Australia. Fl. beautiful red. Shrub.
,, **nigricans.**—Australia. Fl. purple black. Chimbing shrub.
,, **prostrata.** Australia. Fl. beautiful red. Shrub.
,, **rubicunda.** -Australia. Fl. dark purple. Climbing shrub.
,, **splendens.**—Australia. Fl. deep scarlet. Climbing shrub.

Photo by G. Réhaut.

FIG. 65.—*Cassia florida.*

Lathyrus latifolius.—China. Fl. very varied. Climbing herb.
,, **odoratus.**—Southern Europe. Fl. very varied. Climbing herb.
Lessertia annua.—Cape of Good Hope. Fl. red. Herb.
,, **perennans.**—Cape of Good Hope. Fl. red. Herb.
,, **pulchra.**—Cape of Good Hope. Fl. red. Herb.
Lespedeza (divers). Australia. Fl. varied. Under-shrub.
Liparia sphærica. Cape of Good Hope.—Fl. dark yellow. Shrub.
Loddigesia oxalidifolia.—Cape of Good Hope. Fl. rosy white and purple. Under-shrub.
Lotus diffusus. Southern Europe. Fl. yellow. Herb.
,, **Jacobæus.**—Cape Verde Islands. Fl. dull brown. Herb.
,, **suaveolens.**—Southern Europe. Fl. yellow. Herb.
Lupinus (divers). America. Fl. very varied. Under-shrub.

Mirbelia (divers). Australia. Fl. varied. Shrub.
Mucuna (divers). America and India. Fl. varied. Liane.

Neurocarpum guianense.—Guiana. Fl. purple. Under-shrub.
Nissolia fruticosa. Mexico. Fl. yellow. Climbing shrub.

Ononis alopecuroides. Southern Europe. Fl. yellow. Herb.
,, **fruticosa.** Southern Europe. Fl. yellow. Shrub.
Ormosia dasycarpa.—America. Fl. blue. Tree.
Orobus atropurpurea. Algeria. Fl. yellow. Herb.
Ototropis microphylla. Cape of Good Hope. Fl. rose. Herb.
Oxylobium arborescens.—Australia. Fl. yellow. Shrub.
,, **retusum.** Australia. Fl. orange and yellow. Shrub.

Pictetia squamata. East Indies. Fl. yellow. Shrub.
Piptanthus nepalensis. India. Fl. yellow. Shrub.
Platychilum Celsianum. Australia. Fl. Amethyst-blue. Shrub.
Platylobium (divers). Australia. Fl. yellow and purple. Shrub.
Podolobium (divers). Australia. Fl. yellow. Shrub.
Polydaria buscifolia.—Cape of Good Hope. Fl. blue. Shrub.
,, **cuneifolia.** Cape of Good Hope. Fl. white. Sarmentous shrub.
,, **sericea.** Cape of Good Hope. Fl. purple. Shrub.
Pterocarpus echinatus. Philippines. Fl. pale yellow. Shrub.
Pultenæa (divers). Australia. Fl. yellow. Shrub.

Rafnia (divers). Cape of Good Hope. Fl. yellow. Under-shrub.
Retama monosperma. Spain. Fl. white. Shrub.
,, **sphærocarpa.**—Southern Europe. Fl. yellow. Shrub.
Robinia hispida. Carolina. Fl. rose. Tree.

Sophora glauca. East Indies. Fl. rose. Shrub.
,, **mollis.** East Indies. Fl. yellow. Shrub.
,, **violacea.** Ceylon. Fl. blue violet. Shrub.
Sphæroloblum medium. Australia. Fl. red. Under-shrub.
,, **vimineum.** Australia. Fl. yellow. Under-shrub.

[*Photo by G. Réhaut.*

FIG. 66. Flowering branches of *Colvillea racemosa*.

Swainsonia coronillæfolia.—Australia. Fl. purple rose. Shrub.
,, **galegifolia.**—Australia. Fl. brilliant red. Shrub.
,, **grandiflora.** Australia. Fl. rose. Under-shrub.
Sutherlandia frutescens.—Cape of Good Hope. Fl. purple. Shrub.

Tephrosia candida. -Bengal. Fl. white. Shrub.
,, **caribæa.** Caribbee Islands. Fl. red and white. Shrub.
,, **ochroleuca.**—East Indies. Fl. pale yellow. Shrub.
,, **purpurea.**—East Indies. Fl. purple. Shrub.
,, **suberosa.**—Bengal. Fl. rose. Shrub.
Trigonella hamosa. -Egypt. Fl. yellow. Herb.

Uraria crinita.—Indies.—Fl. pink. Shrub.
,, **lagopus.**—Nepal. Fl. purple. Shrub.
,, **lagopoides.** India. Fl. purple. Under-shrub.
,, **picta.** Indies. Fl. purple. Shrub.

Vilmorinia multiflora.—Caribbee Islands. Fl. purple. Plant.

Wistaria chinensis. China. Fl. purplish blue. Climbing shrub.
,, **frutescens.** Carolina. Fl. purple. Climbing shrub.

CÆSALPINIEÆ.

Amherstia nobilis.—East Indies. Fl. yellow and purple. Tree.

Bauhinia arborea. -India. Fl. rose. Tree.
,, **anguina.** East Indies. Fl. pale yellow. Climbing tree.
,, **americana.** Southern America. Fl. white. Shrub.
,, **candida.**- India. Fl. white. Tree.
,, **grandiflora.**—Peru. Fl. white. Shrub.
,, **purpurea.** India. Fl. violet-red. Tree.
,, **racemosa.** India. Fl. pinkish-white. Sarmentous shrub.
,, **Richardsonii.** -Guiana. Fl. white and rose. Tree.
,, **triandra.** West Indies. Fl. purple. Tree.
,, **variegata.** -India. Fl. white and rose. Tree.
Brownea Ariza. -Tropical America. Fl. dark rose. Tree.
,, **coccinea.** Venezuela. Fl. red. Tree.
,, **grandiceps.** -Trinidad. Fl. rose. Tree.
,, **macrophylla.**—Trinidad. Fl. rose. Tree.

Cadia varia.—Arabia. Fl. white and rose. Shrub.
Cassia alata.—Tropics. Fl. yellow. Tree.
,, **aurea.**—Tropics. Fl. yellow. Shrub.
,, **auriculata.**—Ceylon and India. Fl. yellow. Tree.
,, **brasiliana.** -Brazil. Fl. pink. Tree.
,, **corymbosa.** -South America. Fl. yellow. Tree.
,, **fistula.**—Egypt. Fl. yellow. Tree.
,, **florida.**—East Indies. Fl. yellow. Tree.
,, **grandis.**—South America. Fl. rose. Tree.

[*Photo by G. Réhaut.*

FIG. 67.—Stems of *Acacia cultriformis*.

Cassia javanica.—Java. Fl. rose. Tree.
,, **marginata.**—India. Fl. rose. Tree.
,, **multijuga.**—Tropical America. Fl. rose. Tree.
,, **nodosa.** India. Fl. rose. Tree.
,, **rumphiana.**—Java. Fl. rose. Shrub.
,, **sulphurea.** Mauritius. Fl. yellow. Shrub.
Cæsalpinia pulcherrima. America. Fl. red and yellow. Sarmentous shrub.
Cercis siliquastrum.—Western Asia. Fl. rose. Tree.
Colvillea racemosa.—Madagascar. Fl. red. Tree.
Cynometra cauliflora. East Indies. Fl. red. Tree.

Dialium nitidum. Guinea. Fl. purple-red. Tree.

Cleditschia triacanthos.—Canada. Fl. white. Tree.
Cymnocladus canadensis. Canada. Fl. white. Tree.

Hæmatoxylon campechianum. Mexico. Fl. yellow. Tree.
Humboldtia laurifolia. Ceylon. Fl. rose and white. Tree.

Labichea heterophylla. Australia. Fl. yellow. Shrub.

Parkinsonia aculeata. -South America. Fl. yellow. Tree.
Peltophorum ferrugineum. Ceylon. Fl. yellow. Tree.
Poinciana elata. -East Indies. Fl. yellow. Tree.
,, **Cilliesii.** Chili. Fl. yellow. Shrub.
,, **pulcherrima.** -India. Fl. red. Shrub.
,, **regia.** -Madagascar. Fl. red striped with white. Tree.

Saraca declinata. Sumatra. Fl. orange-yellow. Shrub.
,, **indica.** Ceylon and Southern India. Fl. yellow and orange-red. Tree.
Schizolobium excelsum. -Brazil. Fl. yellow. Tree.
Schotia latifolia. Cape of Good Hope. Fl. pale purple. Shrub.
,, **speciosa.** Cape of Good Hope. Fl. crimson. Shrub.
,, **tamarindifolia.** -Cape of Good Hope. Fl. crimson. Shrub.
Swartzia Langsdorffii. Brazil. Fl. white. Shrub.
,, **simplicifolia.** -East Indies. Fl. yellow. Shrub.

MIMOSEÆ.

Acacia cultriformis. Australia. Fl. yellow. Shrub.
,, **dealbata.**—Australia. Fl. yellow. Shrub.
,, **Farnesiana.** The Antilles. Fl. yellow. Shrub.
,, **Julibrissin.**—Orient. Fl. white. Tree.
,, **longifolia.** Australia. Fl. yellow. Shrub.
,, **saligna.**—Australia. Fl. yellow. Tree.
,, **suaveolens.**—Australia. Fl. yellow. Shrub.
,, **vestita.**—St. Helena. Fl. yellow. Tree.
Adenanthera pavonina. -India. Fl. yellowish-white. Tree.
Albizzia mollis. -India. Fl. rose. Tree.

[Photo by G. Réhaut.

FIG. 68.—*Acacia longifolia.*

Calliandra hæmatæephala.—Brazil. Fl. red. Shrub.
,, **Tweedii.**—Brazil. Fl. rose. Shrub.

Dicrostachys nutans.—Africa. Fl. yellow, white, and purple. Shrub

Cagnebina tamariscina.—Mauritius and Bourbon. Fl. yellow. Shrub.

Inga anomala.—Mexico. Fl. red. Shrub.

Mimosa pudica.—Brazil. Fl. pinkish-white. Under-shrub.
,, **sensitiva.**—Brazil. Fl. pink. Under-shrub.

Parkia biglobosa.—Guinea. Fl. vermilion. Tree.
,, **Roxburghii.**—East Indies. Fl. vermilion. Tree.

CHAPTER XVIII.

DISEASES AND PESTS ATTACKING LEGUMINOSÆ.

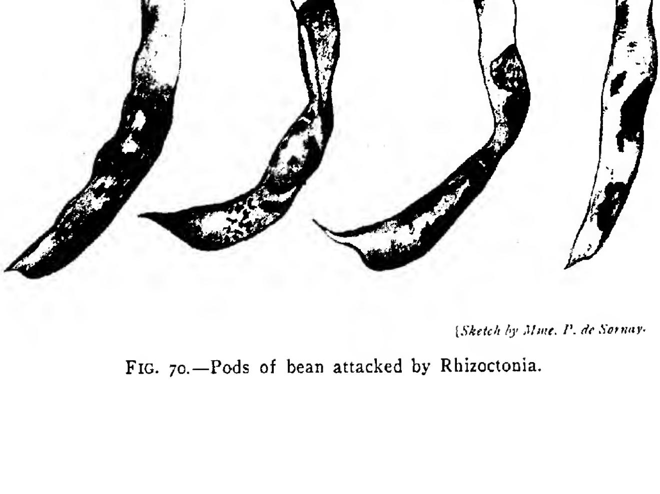
Like those of all other groups, different species of Leguminosæ are subject to different kinds of attack. We have compiled a list of the various enemies of these plants from notes in our possession, and append them in the hope that they may be of use.

Our thanks are due to our friends MM. d'Emmerez de Charmoy, Curator of the Museum, and P. Carié for their kindness in revising the insect classification and for the notes which they have sent us.

Cryptogams	Plants	Parts attacked
Ascochyta pisi	Peas and other legumes ...	Leaves, fruit, stems.
Cercospora personata ...	*Arachis hypogæa*	Leaves.
,, *cruenta* ...	*Vigna Catjang*	Leaves.
,, *sp.*	*Mucuna utilis*	Leaves.
Colletotrichum Lindemuthianum	*Phaseolus vulgaris* and others	Fruit.
Dematophora necatrix ...	Beans	Roots.
Erysiphe communis ...	Peas, clovers, lupins, &c.	Leaves.
Leptogloeum arachidis	*Arachis hypogæa*	Leaves.
Neocosmospora vasinfecta	*Vigna Catjang*	Stems, roots.
Olpidium trifolii ...	Clover	Stems, roots.
Ozonium auriconum ...	Lucerne	Roots.
Peronospora trifoliorum	Clover and others	Leaves.
,, *viciæ* ...	Peas and vetches	Leaves.
Pestalozzia funerea ...	Lupins	Leaves, stems.
Pseudopeziza medicaginis	Lucerne	Leaves.
Pseudopeziza trifolii ...	Lucerne, clover	Leaves.
Pythium de Baryanum...	Clover	Leaves, stems.
Rhizoctonia violacea ...	Lucerne	Roots.
Scherotinia Libertiana ...	Phaseolus	Stems.
,, *trifoliorum*	Clover	Stems, roots.
Thielavia basicola ...	Lupin and others	Stems.
Uredo arachidis	*Arachis hypogæa*	Leaves.
Uromyces Phaseoli ...	Phaseolus	Leaves.
,, *trifolii* ...	Clover	Leaves.
,, *pisi*	Pea	Leaves.
,, *Fabæ*	Vetches	Leaves.

[*Sketch by Mme. P. de Sornay.*

FIG. 69. Pods of bean with blotches of anthracnose.



[*Sketch by Mme. P. de Sornay.*

FIG. 70.—Pods of bean attacked by Rhizoctonia.

Insects and Countries	Plants (Parts attacked)
Coleoptera.	
Chlorida festiva. Barbados	*Albizzia Lebbek.* Stems.
Chalcodermus æneus. United States ...	*Vigna Catjang.* Fruit.
Cœlosterna spinator. India	Acacia. Leaves and stems.
Haploderus spenipermis. Anjouan (Comoros)	*Albizzia Lebbek.* Stems.
Iotherium metallicum (New.). Australia	Acacias. Leaves.
Didymocantha obliqua (New.). Australia	,, ,,
Leptops tribulus (Fab.). Australia ...	,, ,,
TROGOSITIDÆ.	
Tenebroïdes mauritanicus. United States	*Arachis hypogæa.* Fruit.
CUCUJIDÆ.	
Silvanus surinamensis. United States...	*Arachis hypogæa.* Fruit.
SCARABÆIDÆ.	
Anoplognathus flavipennis (Boisd.). Australia	Acacias. Leaves.
Diphucephala aurulenta (Kirby). Australia	,, ,,
BUPRESTIDÆ.	
Diplolophotus insularis (Kerr). Mauritius	*Albizzia Lebbek.* Bark and wood.
Cisseis cyanipes (Saund.). Australia ...	Acacias. Leaves.
,, *leucosticta* (Kirkby). Australia	,, ,,
,, *similis* (Saund.). Australia ...	,, ,,
Agrilus australasiæ (L. & G.). Australia	,, ,,
TENEBRIONIDÆ.	
Toxicum capreolus (Fairm.). Mauritius, Madagascar, the Seychelles, Comoros	*Albizia Lebbek.* Bark and wood.
Trilobium navale. United States ...	*Arachis hypogæa.* Fruit.
Derosphærus globulicollis. Anjouan ...	*Albizzia Lebbek.* Bark and wood.
CURCULIONIDÆ.	
Chrysolophus spectabilis (Fab.). Australia	Acacias. Roots and stems.
Orthorrhinus Klugi (Bohem.). Australia	,, Stems.
Belus bidentatus (Donov.). Australia ...	,, Leaves.
,, *brunneus* (Guer.)	,, ,,
,, *sparsus* (Germ.)	,, ,,
,, *edentulus* (Lea.)	,, ,,
,, *phœnicopterus* (Germ.)	,, ,,
,, *semipunctatus* (Fab.). Australia	,, ,,
Rhinotia hæmoptera (Kirkby). Australia	,, ,,
Myrmacicelus formicarius (Chev.). Australia	,, ,,
Læmosaccus sp. Australia	,, ,,

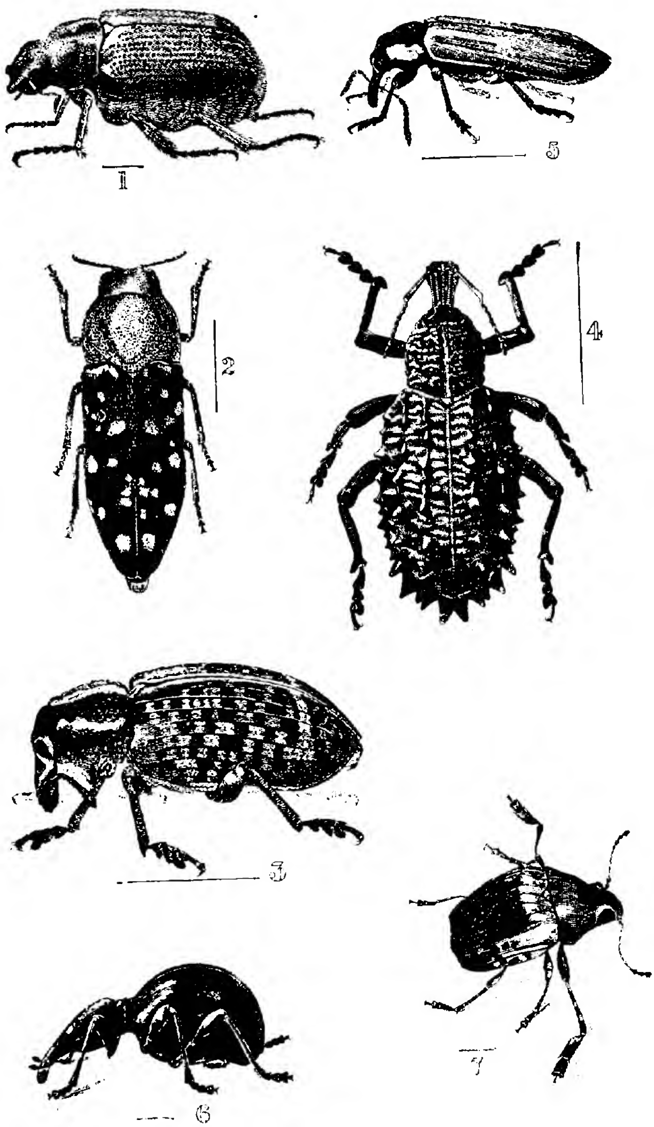


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FIG. 71.—Insects which attack Acacias with tannin-producing bark.
1. *Diphucephala aurulenta* (Kirby). 2. *Cisseis leucosticta* (Kirby). 3. *Chrysolophus spectabilis* (Fab.). 4. *Leptops tribulus* (Fab.). 5. *Rhinotia hæmoptera* (Kirby). 6. *Myrmacicelus formicarius* (Chev.). 7. *Doticus pestilens* (Olliff).

Insects and Countries	Plants (Parts attacked)
Coleoptera (*continued*).	
Anthribidæ.	
Doticus pestilens (Olliff.). Australia ...	Acacias. Leaves.
Bruchidæ.	
Atractocerus brasiliensis (Skinner). Barbados	*Albizzia Lebbek*. Stems.
Bruchus sinensis. East Indies	Phaseolus and Dolichos. Fruit.
,, *quadrimaculatus*. East Indies	,, ,, ,,
,, *nigricornis*	,, ,, ,,
,, *serratus*	,, ,, ,,
,, *prosopis* (Hawaii)	*Cajanus indicus*. Seeds.
Caryoborus gonagra (Hawaii)	*Prosopis Juliflora*. Seeds.
Catorama mexicana (Hawaii)	*Mucuna pruriens*.
Trichothrips nigricans (Hawaii)	*Cajanus indicus*. Pods.
Tetranychus sp. (Hawaii)	Legumes. Pods and leaves.
Hyalopeplus pellucidus (Hawaii)	*Cajanus indicus*. Pods and leaves.
Xiphidium varipenne (Hawaii)	Legumes. Pods and leaves.
Cerambycidæ.	
Pachydissus sericus (New.). Australia ...	Acacias. Leaves.
,, *holosericus*. India	,, Leaves and stems.
Lygesis mendica (Pasc.). Australia ...	,, Leaves.
Uracanthus triangularis (Hope). Australia	,, ,,
Syllitus grammicus (New.). Australia ...	,, ,,
Hebecerus marginicollis (Boisd.). Australia	,, ,,
,, *australis* (Boisd.). Australia	,, ,,
,, *crocogaster* (Boisd.). Australia	,, ,,
Symphyletes vestigialis (Pasc.). Australia	,, ,,
Batocera rubus. East Indies, Mauritius	*Albizzia Lebbek*. Stems.
Prameela sp. Anjouan (Comoros) ...	*Cajanus indicus*. Stems.
Oncideres amputator. Saint Lucia ...	*Inga vera*. Leaves and stems.
Sternotomis cornutor. Anjouan (Comoros)	*Albizzia Lebbek*. Stems.
Xystocera globosa (Oliv.). Mauritius, India, Senegal, the Seychelles, Madagascar, Réunion	,, ,, ,,
Ceresium simplex (Gyll). Mauritius, India, Australia, the Seychelles	,, ,, ,,
Piesarthrius marginellus (Hope). Australia	*Acacia longifolia*. Stems.
Chrysomelidæ.	
Epitrix parvula. East Indies	Legumes. Leaves.
Cryptocephalus sp. Australia	Acacias. Leaves.
Elaphodes tigrinus (Chap.). Australia	,, ,,
Calomela curtisi (Kirby). Australia ...	,, ,,
,, *paralis* (Lea)	,, ,,
Paropsis orphana (Erich.). Australia ...	,, ,,
,, *immaculata* (Marsh.). Australia	,, ,,
Coptocycla sp. East Indies	Legumes. Leaves.

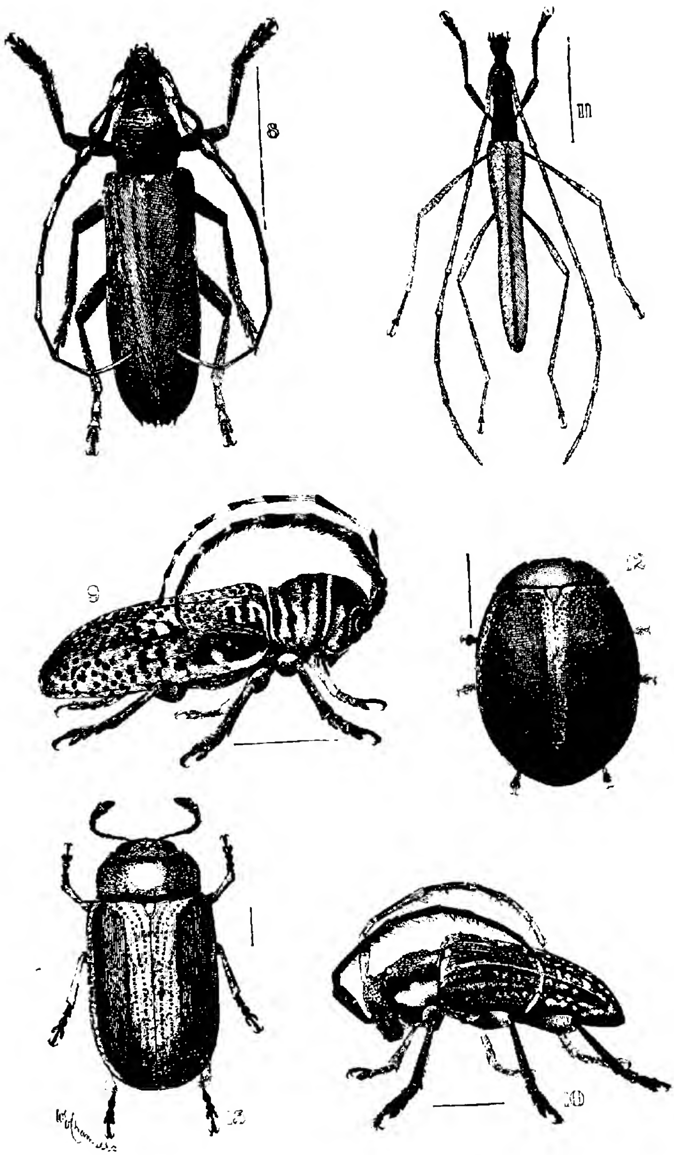

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FIG. 72.—Insects which attack Acacias with tannin-producing bark.

8. *Pachydissus sericus* (Newm). 9. *Symphiletes vestigialis* (Pasc.). 10. *Hebecerus marginicollis* (Boisd.). 11. *Lygesis mendica* (Pasc.). 12. *Paropsis immaculata* (Marsh). 13. *Calomela paralis* (Lea).

Insects and Countries	Plants (Parts attacked)
Lepidoptera.	
Callidryas florella (Fab.). Mauritius, Africa, Bourbon, Mayotte, Madagascar	Cassia. Leaves.
,, *catopsilia*. East Indies ...	,, ,,
Xanthidia floricola (Boisd.). Mauritius, Bourbon, Mayotte, Madagascar	Acacias. Leaves.
Terias sylhetana. Ceylon	*Albizzia Lebbek*.
,, *sp*. Anjouan (Comoros)	*Cajanus indicus*. Leaves.
Lycæna boetica. Mauritius, S. Europe, S. Asia, Africa, Bourbon, Madagascar	*Cajanus indicus*, *Pisum sativum*, &c. Fruit.
Lampides telicanus. Mauritius, S. Europe, S. Asia, Africa, Bourbon, Madagascar	Legumes. Fruit.
Nacaduba Mandersi (Maund.). Mauritius	*Cæsalpinia Bonducella*. Fruit.
Zizera Gaika (Trim.). Mauritius	Legumes. Fruit.
,, *Lysimon* (Hubn.). Mauritius S. Asia, Africa, Madagascar, Bourbon, S. Europe	,, ,,
,, *labradus*. Australia	*Medicago sativa*. Leaves.
Zeuzera eucalypti (Boisd.). Australia ...	Acacias. Leaves.
Psyche sp. Ceylon	Albizzia. Leaves.
Thymele florestan (Cram.). Africa, Mauritius, Bourbon, Madagascar	*Canavalia ensiformis*. Leaves
Euchloris submissaria (Walk.). Australia.	Acacias. Leaves.
Argira cribraria. Mauritius	Crotalaria. Fruit and leaves.
Prodenia retina (As.). Cosmopolitan ...	Legumes. Leaves and stems.
Agrotis upsilon (Rott.). Cosmopolitan...	,, ,, ,,
,, *segetis*. India	Indigofera. Leaves.
Heliothis armigera (De Charmoy). Cosmopolitan.	Peas. Leaves.
Tortrix glaphyriana (Meyr.). Australia	*Medicago sativa*. Leaves.
Plusia Ni (Engr.). Mauritius, Europe, Bourbon, Madagascar	*Lathyrus odoratus*. Leaves.
Polydesma umbricola (Boisd.). Mauritius, Celebes, Bourbon, S. Africa, Madagascar	*Albizzia Lebbek*. Bark.
Ophuisa repanda (Bor.). Mauritius ...	Bonavis bean, cowpeas. Leaves.
Thermesia gemmatalis. East Indies ...	*Phaseolus mungo*, *Cajanus indicus*, *Mucuna utilis*. Leaves.
Ephestia cautella. Mauritius, United States	*Arachis hypogæa*. Fruit.
,, *Kuehniella*. United States ...	,, ,, ,,
Plodia interpunctella. United States ...	,, ,, ,,
Maruca testulalis. Mauritius	Beans. Fruit.
Glyphodes unionalis. Mauritius	*Herbaceous Papilionaceæ*. Leaves.
Bocchoris inspersalis. Mauritius	,, ,,
Dacoleia vulgaris. Mauritius	Bonavis bean, Pois carré, Canavalia, haricot beans. Leaves.
Eudamus proteus. United States	Various peas. Leaves.
Ialmenus evagorus (Don.). Australia ...	Acacias. Leaves.
,, *ictinus* (Hew.). Australia ...	,, ,,
Spodoptera mauritia (Hawaii)	*Canavalia ensiformis*. Leaves.

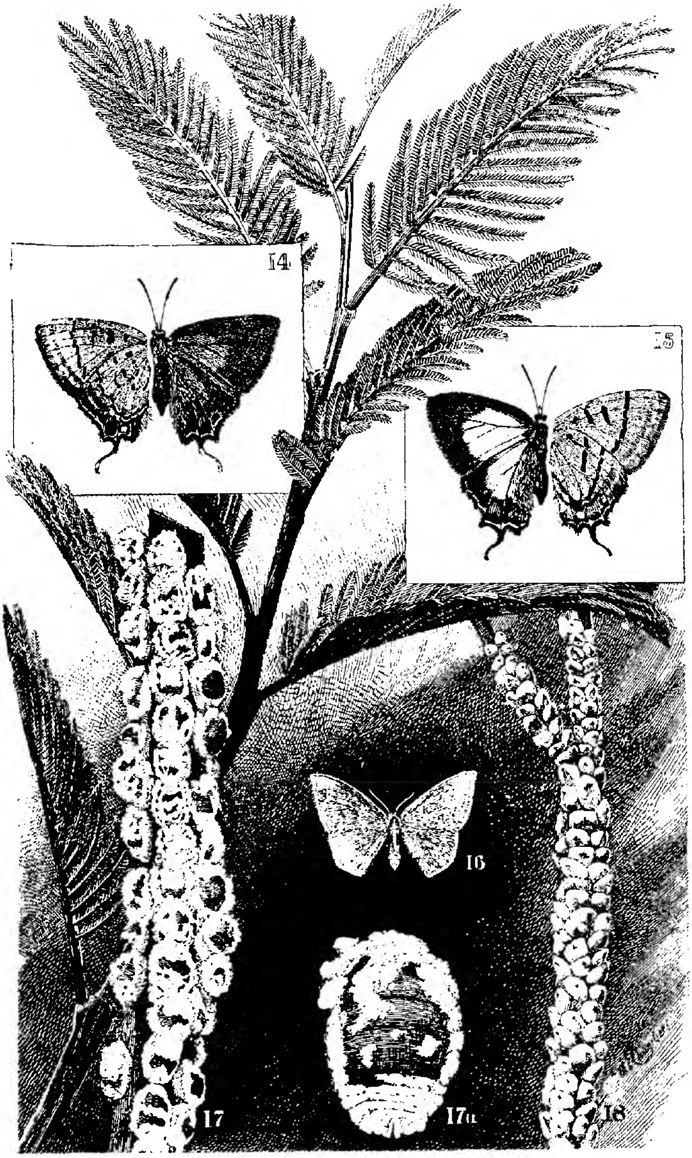

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FIG. 73.—Insects attacking Acacias with tannin-producing bark.

14. *Jalmenus ictinus* (Hew.). 15. *Jalmenus evagorus* (Bon). 16. *Euchloris submissaria* (Walk.). 17. *Dactylopius albizzia* (Mask.). 17a. *Dactylopius albizzia* (Female, magnified). 18. *Lecanium baccatum* (Mask.).

Insects and Countries	Plants (Parts attacked)
Lepidoptera (*continued*).	
Spodoptera exigua (Hawaii)	Peas and beans. Leaves.
Heliophila unipuncta (Hawaii)	*Medicago sativa*. Leaves.
Heliothis obsoleta (Hawaii)	*Cajanus indicus*. Leaves and fruit.
Omiodes monogona (Hawaii)	Legumes. Leaves.
Amorbia emigratella (Hawaii)	,, ,,
Archips postvittanus (Hawaii)	,, ,,
Plusia chalcites (Hawaii)	,, ,,
Diptera.	
Agromyza phaseoli (Coq.). Mauritius, Réunion, Australia	Phaseoleæ. Stems.
,, *sp.* Anjouan (Comoros) ...	*Cajanus indicus*. Stems.
,, *diminuta* (Hawaii)	Peas and beans. Leaves and stems.
Cecidomyia sp. Australia	Acacias. Stems.
Hemiptera.	
Lecanium tessellatum. Mauritius ...	Legumes. Leaves and stems.
,, *longulum*. Hawaii, Fiji ...	*Leucæna glauca*. Stems.
,, *baccatum* (Mask.). Australia	Acacias. Stems.
Asterolecanium pustulans. Brazil, Florida, Sandwich, West Indies	*Cajanus tamarindus*. Stems.
Icerya Seychellarum. Mauritius, Seychelles	Cæsalpinieæ. Leaves and stems.
,, *rosæ* (Riley and How.). Australia	*Acacia sphærocephala*. Bark.
,, *Purchasi* (Mask.). Australia ...	Acacias. Stems.
Orthezia prælonga (Doug.). West Indies	*Hæmatoxylon campechianum*. Stems.
Rhizococcus viridis (Green). Australia...	Acacias. Leaves and stems.
Dactylopius calceolaria. Mauritius, Argentine Republic	*Arachis hypogæa*. *Cicer arietinum*. Roots.
,, *Albizziæ* (Mask.). Australia	*Albizzia lophanta*. Leaves.
Diaspis amygdali. Mauritius	,, *Lebbek*. Bark and stems.
Aspidiotus articulatus. South America...	*Tamarindus indica*. Stems.
,, *cydoniæ*. United States, Ceylon, Mauritius, West Indies	*Canavalia ensiformis*. Stems.
,, *camelliæ* (Sign.). Australia, Mauritius	*Acacia longifolia*. Stems.
Chionaspis minor. West Indies, Porto Rico	*Pithecolobium Saman*, *Cæsalpinia pulcherrima*, *Cajanus indicus*. Stems.
Fiorinia acaciæ. Australia	Acacias. Stems and leaves.
Aphis gossypii. Hawaii	Legumes. Stems and leaves.
,, *sp.* Mauritius	*Vicia faba*. Stems and leaves.
Sextius virescens (Fairm.). Australia ...	Acacias. Bark.
Psylla acaciæ decurrentis (Frog.). Australia	*Acacia decurrens*. Stems.
,, *candida* (Frog.). Australia ...	Acacias. Leaves.
Pseudococcus longispinus (Hawaii) ...	Legumes. Stems and leaves.
,, *citri* (Hawaii)	,, ,, ,,
,, *virgatus* (Hawaii)	,, ,, ,,
,, *filamentosus* (Hawaii) ...	,, ,, ,,
Saissetia oleæ (Hawaii)	*Cajanus indicus* and Crotalaria. Stems and leaves.

[Sketch by P. A. Desvoisseaux.

FIG. 74.

A. Stem of *Cajanus indicus* (Pigeon-pea) showing chrysalids of an undetermined species of *Terias*.

B. Pod of *Mucuna utilis* showing chrysalids of an undetermined species of *Terias*.

AVERAGE ANALYSES.

In the following tables will be found the averages of the analyses occurring through this work. The albuminoid ratio has been calculated on the digestible matter and the nutritive value expressed in starch according to Kellner's method.

The coefficients of digestibility adopted represent the average of the American data and of those of Kellner.

	Seeds per cent.	Forage per cent.	Hay per cent.
Cellulose + sugars + non-nitrogenous matter ...	70	67	43
Fat ...	90	62	50
Nitrogenous matter ...	90	70	65

AVERAGE ANALYSES.

Plants	Common names	Water	Ash	Cellulose	Fat	Sugars	Non-nitrogenous matter	Nitrogenous matter	Nitrogen	Albuminoid ratio	Starch value
GREEN FODDER.											
Acacia aneura ...	Acacia ...	39·06	3·60	29·90	2·55	...	15·83	9·06	1·44	1:5·3	37·78
,, *homalophylla*	,, ...	41·03	8·73	22·59	2·08	—	18·26	7·31	1·17	1:5·8	33·00
,, *pendula* ...	,, ...	48·45	4·45	19·64	1·21	—	16·63	9·62	1·54	1:3·8	30·60
Albizzia Lebbek ...	Blackwood	67·35	2·61	10·18	0·80	...	11·62	7·44	1·19	1:3·0	19·53
Arachis hypogæa ...	Pea-nut ...	79·58	1·58	6·02	1·21	1·37	7·48	2·76	0·43	1:5·2	12·62
Cajanus indicus ...	Pigeon pea	70·00	2·64	10·72	1·65	—	7·88	7·11	1·12	1:2·9	18·36
Canavalia ensiformis	Jack bean	77·33	1·65	6·23	0·68	—	10·45	3·66	0·58	1:4·6	14·71
Cicer arietinum ...	Chick pea	71·00	2·16	11·39	1·03	1·12	9·67	2·73	0·44	1:8·4	16·34
Desmanthus virgatus	...	68·70	2·28	13·21	0·77	—	11·29	3·75	0·60	1:6·6	18·81
Desmodium tortuosum	...	77·80	1·94	6·32	0·26	—	9·37	4·31	0·69	1:3·5	13·03
,, *triflorum*	...	64·00	2·57	12·39	0·92	0·93	13·79	4·80	0·77	1:5·7	21·33
Dolichos bulbosus...	Yam bean	83·06	1·61	5·25	0·77	...	5·19	3·52	0·56	1:3·2	9·81
,, *lablab* ...	Bonavis bean	81·00	1·06	6·71	0·60	1·45	5·06	3·52	0·56	1:3·8	11·33
,, *scarabœoides*	,, ...	69·35	2·34	9·72	1·41	—	12·89	4·29	0·69	1:5·6	18·75
,, *uniflorus*	Horse gram	80·50	1·40	6·08	0·84	0·88	7·06	3·24	0·52	1:4·5	11·94
Galactia ...	,, ...	70·20	2·36	7·42	1·64	traces	13·88	4·50	0·72	1:5·0	18·30
Leucæna glauca ...	Acacia ...	75·00	1·55	3·86	0·32	—	13·94	5·33	0·85	1:3·3	15·08
Medicago sativa ...	Lucerne ...	75·17	2·50	7·82	0·70	...	8·43	5·38	0·85	1:3·1	14·57
,, *lupulina*	,, ...	72·76	2·77	4·29	0·70	—	12·48	7·00	1·12	1:2·4	15·97
Melilotus parviflora	Melilot ...	84·40	2·26	4·13	0·36	—	6·16	2·69	0·43	1:3·8	8·65
Mucuna utilis ...	Bengal bean	82·18	1·44	5·06	0·94	0·58	4·99	4·81	0·77	1:2·4	10·97
Phaseolus helvolus	Ambérique	82·25	1·81	6·65	0·75	1·25	4·53	2·76	0·44	1:4·7	10·53

Phaseolus inamœnus ...	Pois du cap ...	84·76	1·48	4·10	0·61	—	5·86	3·19	0·51	1:3·3	9·07
,, *lunatus* ...	Lima bean ...	78·40	1·64	7·07	0·55	0·76	8·25	3·33	0·53	1:5·3	12·95
,, *semierectus* ...	... ...	78·78	0·86	14·04	0·52	0·36	3·01	2·43	0·39	1:7·2	13·17
Soja hispida ...	Soy bean ...	78·60	1·84	6·80	0·84	0·57	6·90	4·45	0·71	1:3·2	12·89
Trifolium pratense ...	Clover ...	70·80	2·10	8·10	1·00	--	13·60	4·40	0·70	1:5·1	17·74
Vicia sativa ...	Vetch ...	75·00	1·81	5·89	0·62		9·96	6·72	1·07	1:2·4	15·02
Vigna Catjang ...	Cowpea ...	85·70	1·33	4·70	0·59	1·25	4·36	2·07	0·33	1:5·2	8·55
SEEDS.											
Albizzia Lebbek ...	Blackwood ...	12·25	3·73	9·87	2·97	---	44·06	27·12	4·33	1:1·7	64·08
Arachis hypogæa ...	Pea-nut ...	7·48	2·38	3·55	43·75	4·78	9·53	28·53	4·55	1:4·1	119·36
Cajanus indicus ...	Pigeon pea ...	11·60	3·70	5·40	1·44	6·64	51·84	19·38	3·10	1:2·7	61·18
Canavalia ensiformis ...	Jack bean (unripe) ...	75·50	0·93	3·73	0·61	1·38	9·47	8·38	1·34	1:1·5	17·83
,, ,, ...	,, (ripe) ...	14·18	3·41	8·93	2·28	5·30	41·38	24.52	3·92	1:1·9	61·68
Castanospermum australe ...	,, ...	87·10	0·46	0·73	0·23	3·85	5·58	2·05	0·33	1:4·9	8·00
Ceratonia siliqua ...	Carob tree ...	13·00	3·00	6·85	1·25	---	61·40	14·50	2·28	1:3·8	59·56
Cicer arietinum ...	Chick pea ...	11·80	2·75	12·95	3·70	—	50·74	18·06	2·88	1:3·1	64·23
Cyamopsis psoraleoides ...	,, ...	9·83	3·85	8·08	2·81	—	46·00	29·43	4·71	1:1·6	65·80
Dolichos biflorus ...	Horse gram ...	10·30	4·33	5·24	0·76	---	56·91	22·46	3·59	1:2·2	61·33
,, *bulbosus* ...	Yam bean ...	10·40	3·94	6·75	21·60	4·54	27·59	25·18	4·06	1:2·9	88·00
,, *fabæformis* ...	... ...	10·97	3·71	1·38		---	55·00	28·94	4·63	1:1·5	61·56
,, *lablab* ...	Bonavis bean ...	12·47	3·72	7·42	1·19	--	52·65	22·55	3·60	1:2·1	60·87
,, *uniflorus* ...	Horse gram ...	9·70	6·32	4·67	0·96	--	55·85	22·50	3·60	1:2·1	60·26
Ervum lens ...	Lentil ...	12·21	3·20	5·02	0·87	4·83	50·66	23·21	3·71	1:2·1	61·04
Lathyrus sativus ...	Spanish lentil ...	7·89	4·37	4·28	0·79	—	56·36	26·31	4·21	1:1·8	63·64
Leucæna glauca ...	Acacia ...	9·59	3·69	14·00	4·84	—	38·24	29·64	4·74	1:1·6	68·65
Lupinus albus ...	Lupin ...	8·10	4·10	10·15	8·00	-	35·63	34·02	5·45	1:1·5	74·15
Medicago sativa ...	Lucerne (whole fruit) ...	9·50	4·90	21·80	4·30	—	40·55	18·95	3·03	1:3·0	65·24
Mucuna pruriens ...	Cow-itch... ...	10·90	3·50	7·85	3·25	—	45·03	29·47	4·71	1:1·6	65·93
,, *utilis* ...	Bengal bean ...	13·44	3·44	5·45	3·35	3·99	47·05	23·28	3·72	1:2·1	63·20
,, ,, ...	,, unripe ...	58·70	1·45	3·63	1·24	—	25·30	9·68	1·55	1:2·5	29·56
Phaseolus aconitifolius ...	... ...	10·58	3·79	4·70	0·75	—	57·10	23·08	3·69	1:2·1	61·60
,, *helvolus* ...	Amberique ...	12·15	3·47	5·47	1·12	7·35	50·04	20·40	3·25	1:2·5	60·73
,, *inamœnus* ...	Pois du cap ...	14·96	4·38	4·22	1·21	6·20	50·56	18·47	2·95	1:2·7	58·06
,, *lunatus* ...	Lima bean ...	11·70	3·70	6·25	0·94	—	53·29	24·12	3·86	1:2·0	61·33

Plants	Common names	Water	Ash	Cellulose	Fat	Sugars	Non-nitrogenous matter	Nitrogenous matter	Nitrogen	Albuminoid ratio	Starch value
Phaseolus mungo		10·90	3·93	4·75	3·10	...	54·50	22·82	3·65	1:2·2	64·19
,, ,, var. *radiatus*		10·38	4·12	3·80	1·07	—	56·76	23·87	3·82	1:2·0	62·06
,, *semierectus*		9·92	3·36	—	2·00	13·90	48·89	21·93	3·51	1:2·4	63·65
,, *trilobus*		11·20	6·50	7·75	0·59		49·44	24·52	3·92	1:1·8	59·50
,, *vulgaris*	Haricot bean	13·00	3·50	2·85	1·52	—	59·15	19·98	3·18	1:2·5	60·58
Pisum arvense	Field pea	10·12	3·25	4·79	1·21	...	58·63	22·00	3·52	1:2·3	62·62
,, *sativum*	Garden pea (green)	84·10	0·55	1·32	0·28	2·00	8·24	3·51	0·56	1:2·7	9·10
,, ,,	,, (dry)	12·80	2·28	5·20	1·40	—	57·76	20·56	3·29	1:2·5	61·48
Pithecolobium dulce	Manilla cassia	60·00	1·28	7·95	5·51	3·08	13·68	8·50	1·36	1:3·5	33·95
,, *saman*	Guango	10·67	3·51	40·00	5·49	1·57	8·59	24·17	3·87	1:2·0	63·91
Prosopis juliflora	Algaroba	14·38	4·44	6·84	3·94	—	36·78	33·62	5·38	1:1·1	64·62
Psophocarpus tetragonolobus	Pois carré	14·15	3·76	10·72	14·90	7·92	17·85	30·70	4·91	1:2·2	78·39
Soja hispida	Soy bean	8·11	4·63	4·85	16·43	7·65	21·56	36·77	5·88	1:1·6	84·84
Sophora tomentosa	,,	13·56	2·84	19·60	14·00	—	39·70	10·30	1·64	1:7·1	74·39
Tamarindus indica	Tamarind	10·50	2·55	5·36	4·50	—	63·22	13·87	2·22	1:4·4	65·43
Tephrosia candida	Wild indigo	13·40	4·82	13·65	8·50	—	25·88	33·75	5·40	1:1·4	70·78
Trifolium pratense	Clover	9·60	2·80	5·80	8·20	...	42·44	31·16	4·96	1:1·7	73·76
Trigonella fœnum græcum	Fenugreek	10·45	2·87	6·35	6·30	...	48·69	25·34	4·05	1:2·2	69·71
Vicia faba	Bean	13·52	3·08	5·38	1·68	—	50·28	26·06	4·17	1:1·8	61·88
Vigna Catjang	Cowpea	12·05	3·50	5·56	1·22	4·57	49·45	23·65	3·78	1:2·0	61·54
Voandzeia subterranea	Bambarra ground-nut (green)	58·50	1·65	3·03	3·10	...	57·41	7·31	1·17	1:3·9	31·45
,, ,,	,, ,, (ripe)	12·52	3·94	5·65	6·14	—	57·07	14·08	2·34	1:4·2	36·57

VARIOUS.

Albizzia Leblek	Blackwood (dry leaves) ...	9·42	8·48	43·90	3·68	—	25·40	9·12	1·46	1:5·2	37·09
,, ,, ...	,, (pods)	13·40	6·08	37·50	0·70	—	31·82	10·50	1·68	1:4·4	35·08
Arachis hypogæa	Pea-nuts (whole fruit) ...	5·99	2·70	15·93	34·19	2·36	15·12	23·71	3·79	1:3·7	79·35
,, ,, ...	,, (cake)	14·80	7·10	6·19	12·94	—	19·82	39·15	6·26	1:1·5	75·00
Cajanus indicus	Pigeon pea (whole fruit) ...	13·30	3·80	7·50	2·60	—	55·70	17·10	2·73	1:3·7	54·15
,, ,, ...	,, (husks) ...	11·44	4·00	25·00	0·28	—	54·10	5·18	0·82	1:10·1	35·40
,, ,, ...	,, (stems and leaves)	56·65	1·76	15·49	1·12	—	20·12	4·86	0·77	1:7·4	26·95
Canavalia ensiformis	Jack bean (unripe pods) ...	88·18	0·65	1·72	0·30	—	6·84	2·31	0·37	1:3·7	7·24
,, ,, ...	,, (husks)	13·33	6·31	48·75	0·76	—	26·44	4·41	0·71	1:11·5	33·79
Ceratonia siliqua	Carob tree (whole pods) ...	10·96	2·07	9·02	0·46	39·39	32·11	5·99	0·95	1:12·9	55·12
,, ,, ...	,, ,, (husks) ...	12·50	2·30	9·40	0·40	31·25	42·05	2·10	0·33	1:21·5	35·08
Cicer arietinum...	Gram (husks and leaves) ...	8·41	13·11	26·71	2·27	—	45·85	3·65	0·60	1:20·0	50·75
Crotalaria juncea	Sun hemp (hay)	14·39	9·94	27·39	1·12	—	35·85	11·31	2·29	1:3·8	33·52
Dolichos biflorus	Horse gram (husks and leaves)	5·60	8·85	28·01	2·63	—	48·10	6·81	1·09	1:11·3	55·52
,, *bulbosus*	Yam bean (tubercle) ...	84·50	0·56	0·78	0·08	5·03	7·40	1·65	0·26	1:7·7	9·49
,, ,, ...	,, (unripe pods) ...	74·20	1·27	7·74	0·88	—	13·04	2·88	0·45	1:7·1	16·02
,, ,, ...	,, (ripe pods) ...	11·39	4·96	38·29	15·06	—	19·91	10·39	1·66	1:7·9	62·15
,, ,, ...	,, (husks) ...	11·02	4·93	55·55	1·07	—	23·96	3·47	0·56	1:15·7	35·24
Ervum lens	Lentil (husks)	10·40	2·50	27·50	0·50	—	48·68	10·42	1·66	1:4·8	37·62
Hedysarum coronarium	Sulla (hay)	12·88	9·40	23·50	0·88	—	42·72	10·62	1·70	1:4·2	34·08
Lathyrus sativus	Spanish lentil (husks and leaves)	8·59	13·77	19·97	3·96	—	42·40	11·31	1·81	1:5·8	51·38
Leucæna glauca	Acacia (flour)	11·44	4·78	7·80	7·02	—	37·09	31·87	5·10	1:2·2	69·86
,, ,, ...	,, (husks)	12·58	3·42	13·90	3·20	—	55·03	11·87	1·90	1:6·0	61·59
Mucuna utilis	Bengal bean (unripe pods) ...	83·20	0·86	3·87	0·06	—	11·04	0·97	0·15	1:14·7	10·11
Parkia biglobosa	(seeds)	5·70	4·30	2·90	22·75	12·60	15·54	36·21	5·79	1:2·0	94·42
,, ,, ...	(flour)	9·90	4·20	11·65	0·90	31·25	38·47	3·63	0·58	1:17·7	58·56
Phaseolus helvolus	Ambérique (husks) ...	10·76	5·00	37·10	0·76	—	39·26	7·12	1·14	1:7·2	35·92
,, *lunatus*	Lima bean (whole pods) ...	12·68	3·30	18·16	1·52	—	51·72	12·62	2·01	1:5·5	54·10
,, ,, ...	,, (husks) ...	11·62	2·96	40·30	0·78	—	41·84	2·50	0·39	1:22·2	35·47
,, *mungo*	(husks and leaves)... ...	15·38	14·92	17·08	1·70	—	38·24	12·68	2·03	1:4·5	45·20
,, ,, var. *radiatus* ...	(husks and leaves)... ...	13·30	14·29	18·66	2·52	—	39·67	11·56	1·85	1:5·1	47·31
,, *vulgaris*	Haricot bean (green pods) ...	92·00	0·82	0·74	0·28	—	4·17	1·99	0·30	1:2·6	4·73
,, ,, ...	,, (husks) ...	10·70	5·33	36·73	1·03	—	36·97	9·24	1·47	1:5·4	36·39
Pisum sativum	Garden pea (husks and leaves))	12·20	2·50	48·50	1·20	—	29·00	6·60	1.05	1:11·5	54·55

Plants	Common names	Water	Ash	Cellulose	Fat	Sugars	Non-nitrogenous matter	Nitrogenous matter	Nitrogen	Albuminoid ratio	Starch value
Pithecolobium dulce	Manila Cassia (pulp) ...	82·60	0·65	1·98	0·58	8·96	2·63	2·60	0·41	1:5·3	10·94
,, ,, ...	,, ,, (husks) ...	55·70	3·07	14·17	0·51	2·22	19·16	5·17	0·83	1:4·6	18·00
,, ,, ...	,, ,, (whole fruit) ...	70·69	1·48	6·63	1·40	5·94	9·49	4·38	0·70	1:5·3	18·42
,, *Saman*	Guango (pods)	21·15	4·05	12·02	—	26·30	27·71	8·77	1·40	1:7·2	47·35
Prosopis juliflora	Algaroba (pods)	15·26	3·25	24·75	0·58	—	47·27	8·89	1·42	1:5·4	35·08
Psophocarpus tetragonolobus ...	Pois carré (roots) ...	75·40	0·87	1·56	0·58	5·75	13·03	2·81	0·45	1:7·3	15·35
,, ,, ..	,, (tubercles from India)	9·05	3·90	5·38	0·98	—	56·07	24·62	3·93	1:2·5	56·05
,, ,, ...	Pois carré (unripe pods) ..	92·20	0·49	1·70	0·33	1·55	1·67	2·06	0·33	1:2·5	5·21
,, ,, ..	,, (husks) ...	12·80	5·94	36·27	0·75	0·33	37·35	6·56	1·05	1:7·6	34·60
Soja hispida	Soy bean (cake)	14·52	5·16	4·03	8·73	—	25·25	42·31	6·77	1:0·9	71·68
Tamarindus indica	Tamarind (seeds)	9·35	2·45	0·66	6·60	—	62·88	18·06	2·89	1:3·4	69·66
,, ,, ...	,, (pulp)	25·00	3·50	8·00	4·60	42·60	12·94	3·36	0·53	1:20·4	47·66
Tephrosia candida	Wild indigo (husks) ...	10·36	1·60	42·70	0·36	—	39·61	5·37	0·86	1:10·2	36·88
Trifolium pratense	Clover (whole plant) ...	84·50	0·79	4·16	0·44	—	7·90	2·21	0·35	1:5·5	9·57
,, ,, ...	,, (flowers)	77·50	1·19	5·49	0·53	—	11·15	4·14	0·66	1:4·0	13·82
,, ,, ...	,, (leaves)	81·00	1·54	2·29	0·85	—	9·65	4·67	0·75	1:2·7	11·60
,, ,, ...	,, (upper stems) ...	86·60	0·69	3·62	0·35	—	6·93	1·81	0·29	1:5·8	8·24
,, ,, ...	,, (lower stems) ...	85·50	0·43	4·84	0·25	—	8·05	0·93	0·14	1:13·7	9·02
Vicia faba	Bean (flour)	12·40	1·80	1·50	1·54	—	57·27	25·49	4·07	1:1·9	63·14
,, ,, ...	,, (germs)	8·00	3·80	0·62	4·20	—	42·58	40·80	6·52	1:1·2	59·00
,, ,, ...	,, (husks)	10·92	2·76	40·55	0·46	—	40·42	4·89	0·78	1:11·0	36·17
Vigna Catjang	Cowpea (husks)	13·37	3·32	38·00	1·13	—	37·22	6·96	1·11	1:7·3	35·71
Voandzeia subterranea	,, (Bambarra ground nut)	12·50	4·21	9·60	6·41	—	53·17	14·11	2·25	1:5·0	56·38

MINERAL MATTER.

Plants	Common names	Sulphuric acid	Phosphoric acid	Lime	Magnesia	Potash
STEMS AND LEAVES.	*In 100 parts of pure ash.*					
Albizzia Lebbek	Blackwood (dry leaves)	1·49	2·22	41·00	5·58	11·58
Arachis hypogæa	Pea-nut	3·79	5·44	18·08	10·53	22·76
Cajanus indicus	Pigeon pea	5·00	13·82	18·46	6·63	27·74
Canavalia ensiformis	Jack bean	2·80	5·69	33·35	8·85	16·59
Crotalaria	Crotalaria	1·56	4·49	33·29	7·82	17·57
Desmodium triflorum	... ...	1·30	7·80	23·39	2·88	19·50
Dolichos bulbosus	Yam bean	5·40	4·85	15·45	6·77	27·90
,, *lablab*	Bonavis bean	3·01	7·46	18·40	5·58	34·25
,, *uniflorus*...	Horse gram	4·36	5·93	17·62	6·08	35·00
Galactia	... ...	1·91	3·82	28·80	5·02	29·08
Leucæna glauca	Acacia	2·18	5·10	27·60	6·70	24·68
Medicago sativa	Lucerne	3·87	6·59	18·53	6·47	33·44
Mucuna utilis	Bengal bean	3·31	7·00	16·95	6·45	32·00
Phaseolus helvolus	Ambérique	3·52	5·13	13·95	7·99	29·80
,, *lunatus*	Lima bean	2·55	6·35	22·34	8·53	27·83
Psophocarpus tetragonolobus ...	Pois carré (decorticated roots)	4·32	18·91	9·12	19·15	32·15
,, ,, ...	,, (roots undecorticated) ...	7·21	13·83	11·65	5·56	34·71
Tephrosia candida	Wild indigo (stems)	2·46	4·33	26·82	12·69	20·30
,, ,, ...	,, (leaves)	1·72	7·48	25·42	3·32	31·32
Vigna Catjang	Cowpea	3·35	5·77	29·47	10·03	25·06
	In 100 parts of dry matter.					
Arachis hypogæa	Pea-nut	0·295	0·423	1·210	0·817	1·827
Cajanus indicus	Pigeon pea	0·205	0·567	0·757	0·272	1·137

Plants	Common names	Sulphuric acid	Phosphoric acid	Lime	Magnesia	Potash
Canavalia ensiformis	Jack bean	0·200	0·391	2·537	0·670	1·144
Crotalaria	Crotalaria	0·130	0·380	2·867	0·660	1·478
Desmodium tortuosum	...	0·152	0·543	2·337	0·502	2·231
,, *triflorum*	...	0·094	0·568	1·703	0·209	1·419
Dolichos bulbosus	Yam bean	0·534	0·479	1·528	0·669	2·759
,, *lablab*	Bonavis bean	0·265	0·654	1·613	0·489	3·003
,, *uniflorus*	Horse gram	0·314	0·427	1·269	0·438	2·520
Galactia	...	0·151	0·303	2·283	0·401	2·306
Leucæna glauca	Acacia	0·135	0·316	1·711	0·415	1·530
Medicago sativa	Lucerne	0·346	0·590	1·647	0·576	3·007
Mucuna utilis	Bengal bean	0·266	0·561	1·361	0·517	2·567
Phaseolus helvolus	Ambérique	0·368	0·526	1·950	0·813	3·160
,, *lunatus*	Lima bean	0·192	0·480	1·689	0·648	2·103
Psophocarpus tetragonolobus	Pois carré (decorticated roots)	0·154	0·673	0·325	0·682	1·144
,, ,,	(roots, cortical portion)	0·644	1·236	1·041	0·497	3·103
Soja hispida	Soy bean	0·656	0·614	2·417	0·947	1·359
Tephrosia candida	Wild indigo (stems)	0·085	0·368	1·251	0·163	1·541
,, ,,	,, (leaves)	0·362	0·637	3·943	1·864	3·058
Vigna Catjang	Cowpea	0·317	0·550	2·332	0·957	2·393
	In 100 parts of natural substance.					
Albizzia Lebbek	Black wood (dry leaves)	0·126	0·188	3·476	0·473	0·982
Arachis hypogæa	Pea-nut	0·060	0·088	0·287	0·168	0·355
Cajanus indicus	Pigeon pea	0·093	0·257	0·343	0·123	0·516
Canavalia ensiformis	Jack bean	0·043	0·087	0·574	0·148	0·249
Crotalaria	Crotalaria	0·026	0·076	0·579	0·132	0·295
Desmodium triflorum	,,	0·033	0·200	0·601	0·074	0·501

Dolichos bulbosus	Yam bean	0·087	0·078	0·248	0·109	0·449
,, *lablab*	Bonavis bean	0·050	0·123	0·305	0·092	0·568
,, *uniflorus*	Horse gram	0·061	0·083	0·247	0·085	0·490
Galactia		0·045	0·090	0·679	0·118	0·686
Leucæna glauca	Acacia	0·034	0·079	0·428	0·104	0·382
Medicago sativa	Lucerne	0·083	0·140	0·398	0·139	0·718
Mucuna utilis	Bengal bean	0·047	0·100	0·242	0·092	0·456
Phaseolus helvolus	Ambérique	0·063	0·093	0·346	0·146	0·536
,, *lunatus*	Lima bean	0·041	0·058	0·366	0·139	0·455
Psophocarpus tetragonolobus	Pois carré (decorticated roots)	0·037	0·164	0·079	0·166	0·280
,, ,,	,, (cortical portions)	0·119	0·228	0·192	0·092	0·573
,, ,,	,, (whole)	0·062	0·184	0·113	0·142	0·370
Soja hispida	Soy bean	0·170	0·160	0·628	0·205	0·353
Tephrosia candida	Wild indigo (stems)	0·033	0·143	0·486	0·063	0·598
,, ,,	,, (leaves)	0·089	0·157	0·971	0·459	0·753
,, ,,	,, (dry leaves)	0·161	0·441	1·991	0·639	1·955
Vigna Catjang	Cowpea	0·045	0·078	0·326	0·134	0·337
SEEDS.	*In* 100 *parts of pure ash.*					
Albizzia Lebbek	Blackwood	2·66	13·53	14·50	7·58	35·92
Arachis hypogæa	Pea-nut	3·35	38·43	3·72	14·64	34·56
Canavalia ensiformis	Jack bean	3·98	22·93	6·91	8·00	40·28
Cicer arietinum	Chick pea	3·14	15·51	9·10	7·70	38·48
Dolichos bulbosus	Yam bean	1·75	20·45	8·48	8·60	33·96
Phaseolus helvolus	Ambérique	5·07	28·45	4·98	8·35	42·80
,, *lunatus*	Lima bean	1·28	24·36	2·47	7·58	49·36
Psophocarpus tetragonolobus	Pois carré	1·20	29·15	11·12	11·70	33·20
Soja hispida	Soy bean	1·37	29·13	8·92	8·19	45·02
Vigna Catjang	Cowpea	2·71	25·21	3·79	8·52	45·31
	In 100 *parts of seed.*					
Albizzia Lebbek	Blackwood	0·100	0·504	0·541	0·283	1·340
Arachis hypogæa	Pea-nut	0·083	0·943	0·091	0·358	0·843
Canavalia ensiformis	Jack bean	0·134	0·784	0·236	0·274	1·370

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Plants	Common names	Sulphuric acid	Phosphoric acid	Lime	Magnesia	Potash
Cicer arietinum	Chick pea	0·080	0·420	0·250	0·210	1·050
Dolichos bulbosus	Yam bean	0·069	0·806	0·334	0·339	1·338
Phaseolus helvolus	Ambérique	0·183	1·024	0·179	0·301	1·540
,, *lunatus*	Lima bean	0·047	0·901	0·091	0·281	1·826
Psophocarpus tetragonolobus	Pois carré	0·048	1·171	0·447	0·470	1·335
Vigna Catjang	Cowpea	0·104	0·964	0·144	0·326	1·734
Voandzeia subterranea	Bambarra ground-nut	—	0·565	0·115	0·265	1·773
HUSKS.	*In 100 parts of pure ash.*					
Albizzia Lebbek	Blackwood	1·05	5·85	19·28	8·55	27·03
Arachis hypogæa	Pea-nut	2·06	4·07	18·38	4·74	5·93
Canavalia ensiformis	Jack bean	1·56	2·07	8·73	2·00	49·00
Dolichos bulbosus	Yam bean	1·48	2·74	8·30	6·55	42·25
Phaseolus helvolus	Ambérique	0·54	3·54	21·07	16·18	26·35
,, *lunatus*	Lima bean	1·55	6·24	16·65	7·41	32·37
Psophocarpus tetragonolobus	Pois carré	5·41	5·71	4·83	5·35	46·23
Vigna Catjang	Cowpea	1·59	6·59	19·71	16·64	25·65
	In 100 parts of husks.					
Albizzia Lebbek	Blackwood	0·064	0·355	1·172	0·520	1·643
Arachis hypogæa	Pea-nut	0·058	0·118	0·536	0·129	0·170
Canavalia ensiformis...	Jack bean	0·102	0·136	0·555	0·129	3·088
Dolichos bulbosus	Yam bean	0·073	0·125	0·409	0·323	2·083
Phaseolus helvolus	Ambérique	0·027	0·177	1·053	0·809	1·318
,, *lunatus*	Lima bean	0·045	0·184	0·492	0·219	0·958
Psophocarpus tetragonolobus	Pois carré	0·319	0·336	0·285	0·315	2·727
Vigna Catjang	Cowpea	0·052	0·219	0·655	0·553	0·852

BIBLIOGRAPHY.

Annales agronomiques françaises et étrangères.
Annales de la Science agronomique (DEHÉRAIN).
L'Agriculture pratique des Pays chauds.
Journal d'Agriculture tropicale.
Revue Scientifique.
Rapports de la Station agronomique de l'Ile Maurice.
The Tropical Agriculturist (Ceylon).
The Agricultural News.
Queensland Gazette.
Agricultural Ledger.
Journal d'Agriculture pratique.
Revue Agricole de la Réunion (DE VILLÈLE).
Annual Reports of the Hawaii Agricultural Experiment Station.
Bulletin économique de l'Indo-Chine.
The Agricultural Journal of the Union of South Africa.
The Indian Trade Journal.
West Indian Bulletin.
Revue coloniale.
Revue des Cultures coloniales.
The Empire of Brazil at the Universal Exhibition of 1876.

ACHART.—*Quinze cents Plantes dans l'Inde.*
BAKER.—*Flore de Maurice.*
BALLAND.—*Les Aliments.*
BENTHAM and HOOKER.—*Genera Plantarum.*
BLOCH (Dr.).—*Le Soja.*
BOJER.—*Hortus Mauritianus.*
BRANDIS.—*Indian trees.*
BURKILL.—*Goa Beans.*
CHARABOT.—*Productions végétales des Colonies françaises.*
CONSTANTIN.—*Le Monde des Plantes.*
CONSTANCIA.—*Essences forestières du Soudan.*
CORDEMOY (J. DE).—*Gommes et résines d'origine exotique.*
,, *Flore de la Réunion.*
CORNEVIN.—*Plantes vénéneuses.*
COSSIGNY.—*Moyens d'Améliorations des Colonies.*
COURTET (H.).—*Les Bois de la Côte d'Ivoire.*
DECAISNE and NAUDIN.—*Manuel de l'Amateur des Jardins.*
DELACROIX and MAUBLANC.—*Maladies parasitaires des Plantes.*
DENAIFFE.—*Les Haricots.*
,, *Les Pois potagers.*
DON (G.).—*A General History of the Dichlamydeous Plants.*

Dybowski (J.).—*Traité pratique de Cultures tropicales.*
French.—*Handbook of the Destructive Insects of Victoria.*
Froggatt.—*Australian Insects.*
Gamble.—*Manual of Indian Timbers.*
Grandeau.—*Cours à l'Ecole forestière.*
Heuzé.—*Plantes industrielles.*
Jacques and Herincq.—*Manuel des Plantes.*
Jumelle (H.).—*Cultures coloniales.*
,, *Ressources agricoles et forestières des Colonies françaises.*
Lanessan.—*Plantes utiles des Colonies françaises.*
,, *Histoire naturelle médicale.*
Leather.—*Food Grains of India.*
Lecomte (H.).—*La Production agricole et forestière dans nos Colonies.*
Le Maout.—*Flore des Jardins.*
Lindley and Moore.—*Treasury of Botany.*
Linné.—*Species plantarum.*
Li-Yu-Ying and Grandvoinnet.—*Le Soja.*
Maiden.—*Gums and Resins of Australia.*
Naudin.—*Manuel de l'Acclimateur.*
Nicholls and Raoul.—*Petit Traité d'Agriculture tropicale.*
Oliver.—*Flora of Tropical Africa.*
Pailleux.—*Le Soja.*
Pailleux and Bois.—*Le Potager d'un Curieux.*
Pairault (A.).—*Les Plantes comestibles féculentes cultivées aux Antilles.*
Pellet (H.).—*Sur la Fixité de Composition des Végétaux. Analyse du Soja.*
Pennetier (Dr.).—*Leçons sur les Matières premières organiques.*
Pouchat (J.).—*Légumes indigènes.*
Prilleux.—*Maladies des Plantes.*
Sagot.—*Cultures tropicales.*
Sebert. *Notice sur les Bois de la Nouvelle Calédonie.*
Sornay (P. de).—*Etude sur les Légumineuses.*
Stebbing.—*Injurious Insects of Forest Trees.*
Treub.—*Annales de Buitenzorg.*
Trimble.—*Le Soja.*
Van Tieghem.—*Botanique.*
Vesque.—*Botanique.*
Watt (G.).—*Dictionary of Economic Products of India.*

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WHEN MANURING YOUR CROPS

do not forget to include the necessary proportion of AVAILABLE NITROGEN in the form of

NITRATE OF SODA

with the complete manures that you will require in addition to the

GREEN MANURES.

NITRATE OF SODA counteracts drought in the soil and hastens the maturing of crops, and when labour is scarce and dear and the ground hard to work through absence of moisture, it will pay to apply a light dressing of Nitrate of Soda at a small cost per acre, especially when it is desired to bring along the crop before the rains come.

NITRATE OF SODA FOR WHEAT.

With wheat in India the average yield of the same land has been increased from 13 to 20 maunds owing to its having been properly fertilized, but where the land is only occasionally manured the crops are poor.

NITRATE OF SODA FOR MAIZE.

In many districts deep ploughing is a mistake, and when this is the case the land should be lightly cultivated and the nitrogen required supplied in the form of Nitrate of Soda. A practice that very materially reduces Maize yields in the Philippines, we are told, is deep ploughing instead of shallow cultivation after the root systems are well developed. This destructive mode of cultivation is practised with sugar-cane and tobacco as well as with maize. Maize requires to be well supplied with plant food in order to increase its carbohydrates, fat, and protein contents, but this does not mean that the crop should be too heavily fertilized, as to do so is a mistake.

NITRATE OF SODA FOR TOBACCO.

Investigations in the Botanical area at Pusa go to show that tobacco after sunn-hemp (*Crotalaria juncea*) does not ripen off as sharply or evenly as that grown with farmyard manure and that supplementary manures—*i.e.*, artificials—may be necessary.

Tobacco planters therefore, in India and elsewhere, should carry out experiments to ascertain the best proportion of nitrate of soda for their tobacco crops, and how and when such applications should be made.

NITRATE OF SODA FOR SUGAR-CANE.

Experiments carried out in Travancore go to prove that the application of a complete manure is beneficial to sugar-cane crops. In these days when it is essential that every area that can produce cane-sugar should do so as freely as possible, planters must see that they apply the most suitable complete manure to their crops. Judging from what has been done in Hawaii, where we are told the average yield in 1911 was about nine tons of sugar per acre, as compared with one ton or less in India, sugar producers within the Empire can, by a judicious use of nitrate of soda, greatly increase their yield per acre. By doing so the cost of labour, irrigation water, &c., per ton of sugar produced will be on a much lower scale than it is at present, since anyone can understand that it costs far less per ton of sugar if nine tons of sugar are obtained per acre, instead of requiring nine acres or more to produce the same amount.

Great stress has been laid by experts on the necessity of the cane attaining maturity before being cropped, and when the sucrose content is at its maximum. Returns given show that this content increases from 2·70 to 15·86 per cent. in the same cane, whilst Java returns go up to 18·77, and returns even as high as 20 per cent. and 22 per cent. are spoken of in the West Indies.

Hawaii, which spent in 1910 $60 an acre on artificial manures, obtained up to 8·8 tons of sugar on selected estates, according to Gerligs, and in Java the crop is very generously fertilized, manures supplying nitrogen being exclusively used.

In Hawaii, according to *Tropical Life*, the practice is to use a complete fertilizer containing a considerable amount of nitrogen, and later on to top dress with a liberal quantity of nitrate of soda. It is stated that as much as 1,000 lbs. of nitrate of soda per acre has been applied in three separate dressings, and that this paid well. It is, we are told, quite a common thing to use from 600 to 800 lbs. of nitrate of soda in Hawaii, which shows that what may appear to be extravagant fertilizing gives excellent financial results.